ADMIRALTY MANUAL OF SEAMANSHIP 1967

VOLUME II

Admiralty Manual of Seamanship

VOLUME II

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Change No. 1

1. This Change consists of three pen-and-ink notations and one amendment to be cut out and pasted into the book. The insertion of this Change is to be recorded on the inside of the front cover.

2. PEN-AND-INK AMENDMENTS:

Page 388, Strength of rig, line 8: *delete* 'and', *insert* 'of'.

After page 559, Plate 2 of Lights, Daymarks and Fog Signals of Vessels (1960), against the second illustration: after 'black diamond shape' *insert* 'See amendment pasted in on page 562'.

Page 566, in margin against Rule 3: *insert* 'See amendment pasted in on page 562'.

3. CUT-OUT AMENDMENT:

Cut out the amendment headed 'Towing Vessels—Second Masthead Light' and paste it in the blank space on page 562.

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Towing Vessels—Second Masthead Light

1. Some doubt has risen whether the wording of Rule 3 of the International Regulations for Preventing Collisions at Sea 1960 requires vessels over 150 feet in length to carry a second masthead steaming light in accordance with Rule 2 (*a*) (ii) when towing or pushing another vessel. The Board of Trade has issued Merchant Shipping Notice No. M518 to clarify this issue, and the notice is reprinted below.

International Regulations for Preventing Collisions at Sea, 1960

Second masthead light to be exhibited by vessels of 150 feet or over when towing or pushing.

Notice to Shipowners, Shipmasters and Seamen and others concerned with foreign-going and home trade merchant ships and fishing vessels.

The Board have been considering a possible ambiguity in the wording of the International Regulations for Preventing Collisions at Sea 1960* concerning the second masthead light prescribed for vessels of more than 150 feet in length when towing or pushing.

According to Rule 2(*a*) (ii), a vessel of more than 150 feet in length shall carry the second masthead light when under way. Rule 3, however, (which deals with lights and shapes to be exhibited by vessels when towing or pushing) by being explicit on the carriage of the sidelights, the towing lights (2 or 3 in a vertical line) and the stern light, and by omitting reference to the second white masthead light, creates an element of doubt about whether it needs to be shown. Thus, the question was raised whether a vessel of 150 feet or more in length, when towing or pushing another vessel or seaplane, was required to comply with Rule 2(*a*) (ii).

This matter was raised with the Intergovernmental Maritime Consultative Organisation and after reference to their Sub-Committee on Safety of Navigation it was considered by their Maritime Safety Committee. An extract from the report of this Committee is appended below for the information of all concerned:

"The Committee, holding the view that the intention behind Rule 3 (*a*) of the International Regulations for Preventing Collisions at Sea seen in conjunction with Rule 2(*a*) (ii) was that the second masthead light be carried by vessels of 150 feet or over in length when towing or pushing, wished to recommend that governments bring this to the attention of all concerned through the usual channels.'

*Set out in SI 1965 No. 1525 (The Collision Regulations (Ships and Seaplanes on the Water) and Signals of Distress (Ships) Order 1965). HMSO, 1s. 6d.)

2. **H.M. Ships, R.F.A.s, Marine Services Vessels and P.A.S. craft over 150 feet in length that are fitted with a second masthead light in accordance with Rule 2(*a*) (ii) of the Rule of the Road (1960) are to display this light in addition to the lights required by Rule 3 when towing or pushing another vessel.** (Change No. 1)

PREFACE

The *Admiralty Manual of Seamanship* is in three volumes. *Volume I* is the basic book of seamanship for officers and men joining the Royal Navy. *Volume II* contains more technical detail and is a general textbook and reference book for ratings seeking advancement and for junior officers. *Volume III* is intended mainly for officers. It covers such essential seamanship knowledge as the handling of ships and also information on a variety of subjects that could be classed as advanced seamanship, such as aid to ships in distress.

The chapters in each volume are arranged in the following four Parts, dealing generally with the subjects shown:

PART I: *Ship Knowledge and Safety*. Types of ship and their construction; firefighting; stability; control of damage; lifesaving.

PART II: *Seamanship*. The uses of rope; rigging; sailing boats and power boats; anchors and cables; evolutions such as towing, salvage and lifting or moving heavy loads.

PART III: *Ship Organisation*. General organisation of a ship; naval communications; ceremonial; ship upkeep and ship husbandry.

PART IV: *Shiphandling and Navigation*. Steering; elementary navigation and pilotage; handling of ships in different conditions; the Rule of the Road.

It is hoped that the volumes may also prove useful outside the Royal Navy, to all who put to sea in ships or boats.

(N/DNTC 72/64)

CONTENTS

PART I

SHIP KNOWLEDGE AND SAFETY

CHAPTER 1

Elementary Ship Stability

A seaman should know the elementary principles of ship stability to enable him to load his vessel with cargo or passengers without endangering her seaworthiness. Such knowledge will also enable him to take the best measures for ensuring the safety of his vessel should her seaworthiness be endangered through the effects of collision, storm, or enemy action. The elementary principles governing the buoyancy and stability of a ship are therefore described in this chapter. A more advanced treatment of the subject is given in Vol. III.

The stability of a ship in the transverse or athwartships direction is much more easily prejudiced than that in a fore-and-aft direction; this chapter is therefore almost wholly concerned with transverse stability.

Flotation

A flat sheet of metal placed in a tank of water will sink to the bottom, and the volume of water which it displaces will be equal to the volume of the sheet of metal. If the sheet of metal is moulded into the form of a watertight box it will float on the surface of the water, and the volume of water then displaced will be equal to the volume of the immersed part of the box, and its weight will be equal to the weight of the box.

These facts are illustrated in fig. 1–1, which represents a boat weighing 2·6 tons lowered into a tank of water. When the boat is waterborne, 2·6 tons of water are displaced, the volume of which is equal to the immersed volume

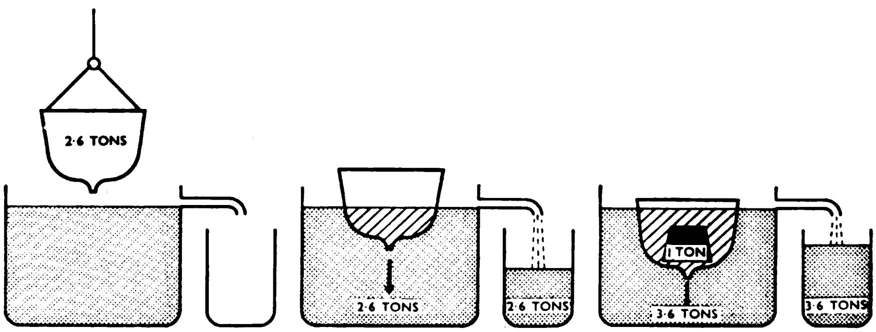


FIG. 1–1. Flotation and displacement

(shown shaded) of the boat. If a weight of one ton is placed in the boat she will sink down into the water until 3·6 tons of water are displaced, and the volume of water displaced will be equal to the volume (shown shaded) of the immersed part of the boat.

If the boat heels to one side the shape of the immersed portion of her hull will alter, but the volume will remain the same. In fig. 1–2 the volume of the

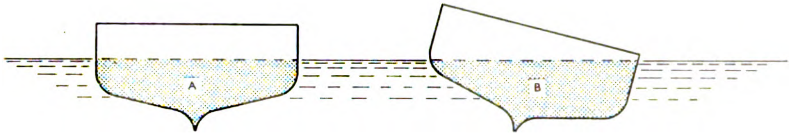


FIG. 1-2

shaded portion *A* equals that of the shaded portion *B*, and the weight of water displaced by the volume of *A* equals the weight of water displaced by that of *B*.

Buoyant volume

The buoyant volume of a ship is the volume of the entire watertight part of the hull. That portion of the buoyant volume below the waterline is called her *buoyancy*, and that portion above the waterline is called her *reserve of buoyancy*.

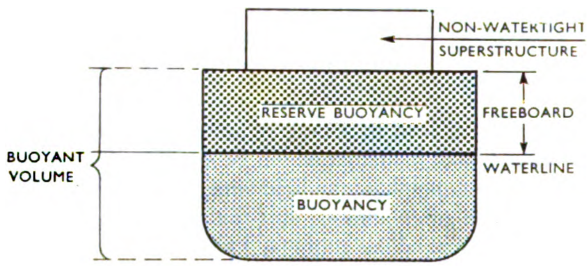


FIG. 1-3. Buoyant volume

The *freeboard* is the height above the waterline at the ship's side of the highest continuous watertight deck. As most ships are nearly wall-sided (i.e. perpendicular) above the waterline the freeboard gives an approximate measure of the reserve of buoyancy.

Centres of gravity and buoyancy

A ship's ability to float depends upon two factors, her weight and her buoyancy.

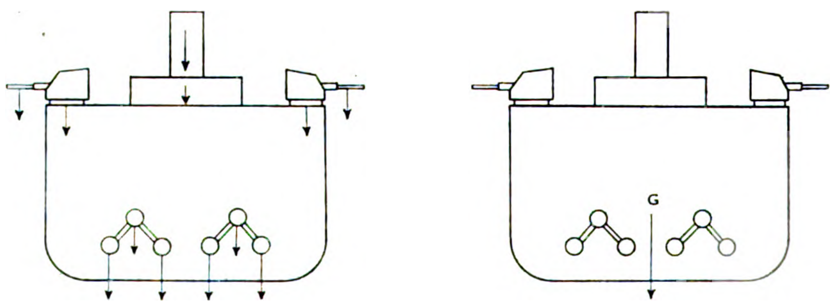


FIG. 1-4. Centre of gravity

By her weight is meant the sum of the weights of everything in the ship, including that of all the structure, machinery, armament, fittings, stores, fuel, crew, cargo and passengers, and its effect can be visualised as exerting a single force through a central point which is called the *centre of gravity* (usually indicated by the letter *G*—see fig. 1–4).

By her buoyancy is meant the upward force exerted on the ship's hull by the water when she is floating, and it is equal to the weight of water she displaces. Although this force is distributed over all the underwater surface of the ship's

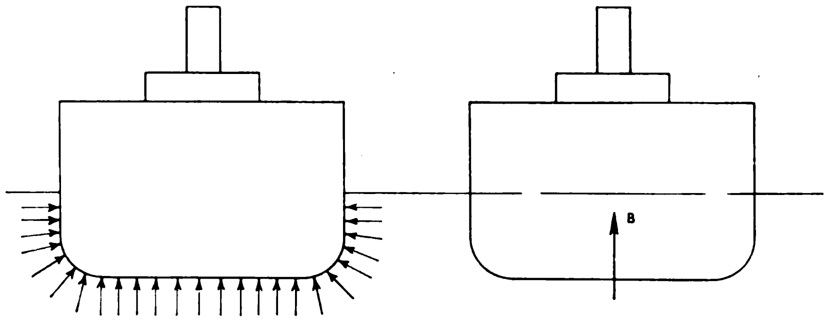


FIG. 1–5. Centre of buoyancy

hull it also can be resolved into a single force exerted through a central point which is called the *centre of buoyancy* (usually indicated by the letter *B*—see fig. 1–5).

A ship's hull is symmetrical about a fore-and-aft vertical plane, so *B* is on the middle line when the ship is floating upright; and as the weight in this condition must be distributed symmetrically about this plane, *G* is also on the middle line.

CONDITIONS FOR EQUILIBRIUM

For a ship to float in equilibrium the buoyancy force pushing upward on the underwater part of the hull must be equal to the total weight of the ship, and as these two forces balance one another they must be acting in the same straight line (fig. 1–7 (i)).

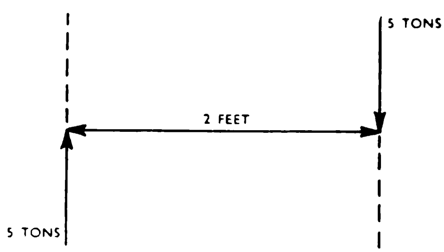
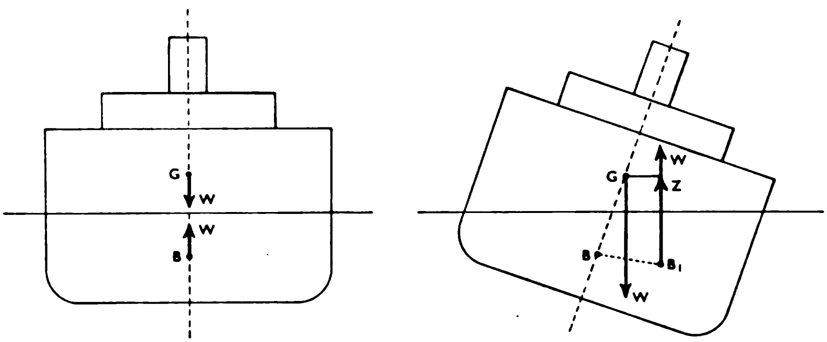


FIG. 1-6

When two equal and opposite forces acting on the same object are not in line they produce a moment tending to rotate the object: this moment is found by multiplying the perpendicular distance between the lines of action of the forces by the force of one of them; example (fig. 1–6):

Moment = 5 tons × 2 ft = 10 tons ft

If a ship is heeled over by some external force such as wind or wave, the weight—and hence the position of the centre of gravity—will remain unaltered; but as the shape of the submerged part of the hull will be changed, the centre of buoyancy, *B*, will move from the middle line towards the lower side of the ship, as shown in fig. 1–7 (ii). Here the forces of weight and buoyancy are out of line and therefore produce a moment tending to rotate the ship. If this moment tends to return the vessel to an upright position (as shown in fig. 1–7 (ii)) she is said to be in ***stable equilibrium***.



(i) (ii)

FIG. 1-7

Righting moment and righting lever

In fig. 1–7 (ii) the ***righting moment*** acting on the ship is calculated by multiplying the displacement, *W*, by the horizontal distance between the resolved forces of weight and buoyancy, *GZ*.

The horizontal distance *GZ*, which separates the forces of weight and buoyancy as the ship heels, is called the ***righting lever***.

The stability of a ship (i.e. her resistance to heeling forces) at any angle of heel is given by her righting moment which depends upon the size and shape of the submerged part of the hull (which determines the position of *B*) and also on the distribution of the weights of stores, fuel, guns, cargo, machinery, etc. (which determines the position of *G*).

As the weight and centre of gravity of a ship remain unaltered (apart from small differences due to free liquids) when she is heeled by an external force, her stability can be judged by the length of the righting lever *GZ* at the particular displacement.

Thus it will be seen that the stability of a ship depends on three factors:

1. The shape of her hull (both of the portion normally under water and the

portion liable to be submerged as the ship rolls), which determines the position and movement of the centre of buoyancy.

2. The arrangement of weights such as engines, boilers, guns, cargo, which determines the position of the centre of gravity.
3. The positions of the centres of gravity and buoyancy in relation to each other and to the ship, which determine her stability.

In designing a ship's hull a compromise must be reached between the requirements of speed, capacity and stability. Too much weight above the centre of gravity—due to superstructures, guns, radar equipment, derricks, and deck cargo, for example—may raise the centre of gravity sufficiently to endanger her stability, thus making her top-heavy. A ship whose beam is unduly narrow may not have a sufficiently large or powerful righting lever to enable her to recover from a heavy roll.

A warship must be designed with a sufficient margin of stability to keep her stable when damaged and partly flooded.

Period of roll

When a ship is rolling, the righting moment produced depends upon the severity of the roll, i.e. upon the angle of inclination of the ship from the vertical. This righting moment ($W \times GZ$ in fig. 1-8) will oppose the roll away from the upright position and hasten the roll back to it.

A ship with a large righting moment (i.e. good stability) will usually roll rapidly. Conversely, a ship with a small righting moment (i.e. poor stability) will usually roll sluggishly. The period of a ship's rolling can thus give an indication of her stability.

A ship which is too lively will be uncomfortable; her violent movements may even carry away her masts and other fittings, and, if a warship, she will not afford a sufficiently stable gun platform. If too sluggish, however, she will be unsafe in heavy weather, so a compromise in these respects has to be achieved by the designer.

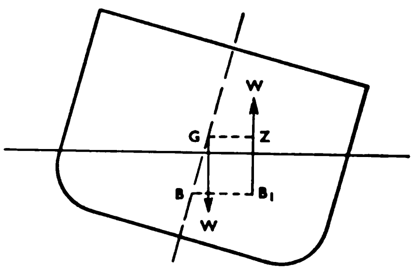


FIG. 1–8. Period of roll

Heel and trim

Heel is a ship's athwartships inclination either side from the vertical, however caused; a sailing vessel, for example, may be heeled by the wind to her leeward side.

List is a heel caused by off-centre loading, i.e. G is not on the middle line.

Trim describes the inclination of the ship's designed horizontal fore-and-aft plane with the surface of the water in which she floats. When in normal trim this plane lies parallel with the surface of the water; she may, however, be trimmed (down) by the bows or stern.

EFFECTS OF LOADING, LIST, BALLAST AND TOP-WEIGHT

Effect of loading a ship

The effect on her stability of adding a weight to a ship will depend on the size and position of the weight, but it will always result in the mean draught of the ship being increased and in her centre of gravity being moved towards the added weight. The latter effect can be illustrated by the simple example given in figs. 1–9 and 1–10. If two equal weights are hung equidistantly from the

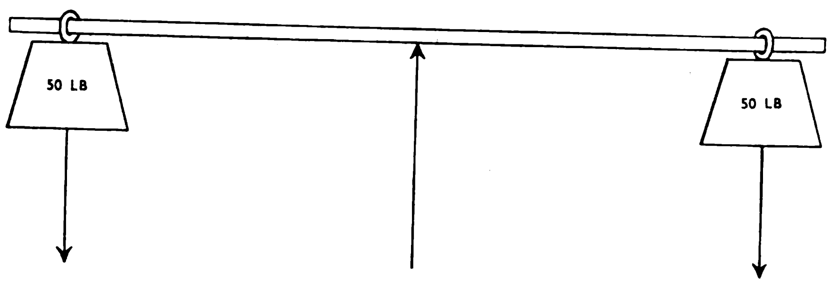


FIG. 1-9

middle point of a metal bar it will balance about that point, because that is the centre of gravity of the whole (fig. 1–9). If another weight is added on one side of the support (as shown in fig. 1–10), the support will have to be moved from

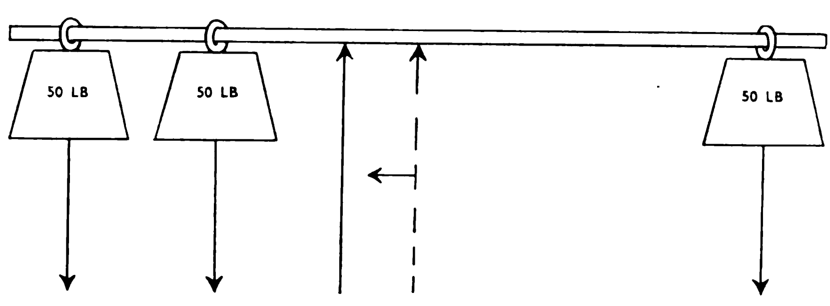


FIG. 1-10

the middle towards the heavier end in order to preserve the balance of the whole. In other words, the centre of gravity of the whole has moved towards the added weight.

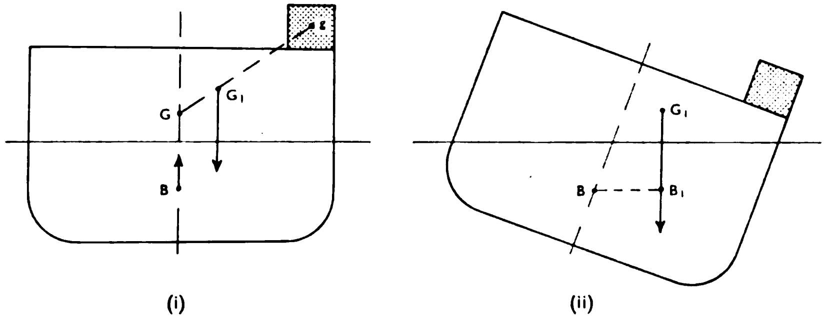


FIG. 1–11. Effect of off-centre loading

Off-centre loading

When a heavy weight is added on either side of a ship, her centre of gravity moves towards that of the added weight, i.e. from G to G_1 in fig. 1–11 (i). The weight and buoyancy forces are no longer in the same straight line and so they produce a moment which will list the ship towards the side on which the weight was added. As the ship lists, so B moves towards the side on which the weight was added—that is, towards the low side—until it reaches position B_1, vertically below G_1, as shown in fig. 1–11 (ii). Then, with the centres of buoyancy and gravity once more in the same vertical line, the ship will float in equilibrium in the inclined or listed position. The opposite effect is caused by removing a weight, i.e. the centre of gravity moves *away* from the centre of gravity of the removed weight and the ship will list away.

Effect of list on stability

It may be said that the stability of a ship is reduced by a list because G has moved off the middle line. Any further heel by an external force in the same direction as the list will produce a smaller righting lever at the particular angle of heel than it would if G were still on the middle line; in fig. 1–12, for example, G_1Z_1 is less than GZ.

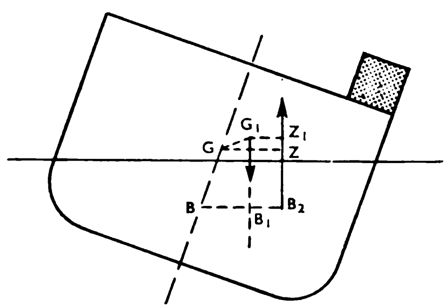


FIG. 1–12. Effect of list on stability

Righting levers will, however, be correspondingly increased if the ship is heeled away from the list.

Ballast

If a weight is added low down on the middle line of a ship it will have the effect of lowering the centre of gravity, e.g. from G to G_1 in fig. 1–13 (i). This will improve her stability, because it increases the righting lever at any angle of heel. The righting lever after ballasting, $G_1 Z_1$ in fig. 1–13 (ii), is greater than the original righting lever GZ. A similar effect results from lowering weight vertically in the ship. Removal of weight from low in the ship, however, raises G and reduces stability.

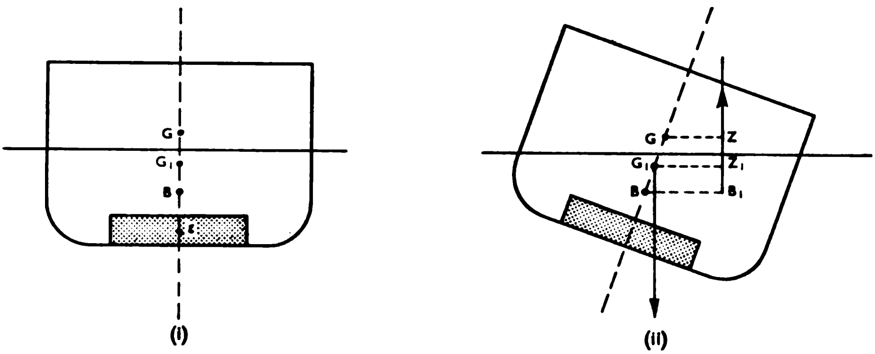


FIG. 1–13. Effect of ballast

Top-weight

If a weight is added high in the ship the centre of gravity will be raised (e.g. from G to G_2 in fig. 1–14 (i)) and the stability will then be reduced. In fig. 1–14 (ii), for example, $G_2 Z_2$ is less than GZ. Top-weight is therefore dangerous and should be avoided as much as possible. A similar effect results from raising weight vertically in a ship. Removal of top-weight, however, lowers G and improves stability.

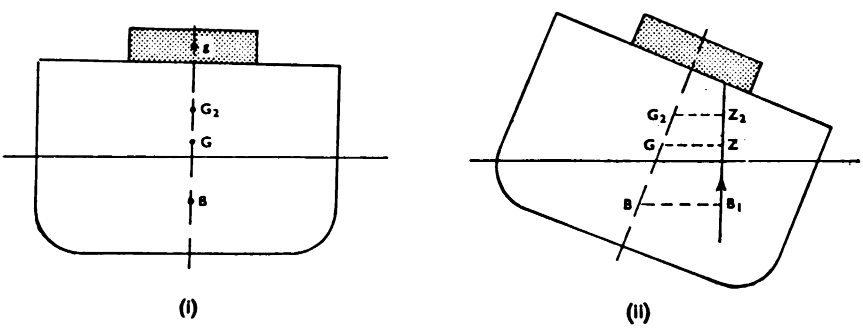


FIG. 1–14. Effect of top-weight

EFFECTS OF FLOODING AND FREE-SURFACE LIQUID, AND METHODS OF COUNTERING

Completely flooding a compartment will have exactly the same effect on the stability of a ship as adding a solid substance of equal weight at the centre of gravity of the flood-water. For example, completely filling a centre-line fuel tank would ballast the ship and so improve her stability.

Free-surface liquid

If a fuel or other tank is only partly filled, however, the liquid in it has what is called a *free surface*, being free to run across to the low side as the ship heels or rolls. This will have the effect of moving the centre of gravity of the ship towards the low side, thus reducing the righting lever, so that in the example shown in fig. 1–15, $G_1 Z$ is less than GZ.

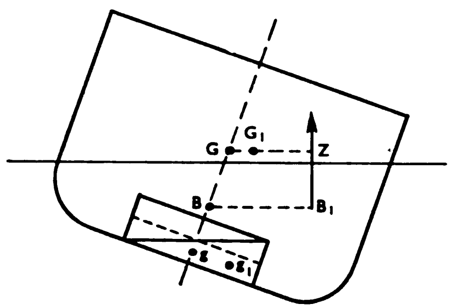


FIG. 1–15. Effect of free-surface liquid

Free-surface liquid therefore reduces stability, and the *free-surface effect* depends on the area (mainly width) of the free-surface liquid but not on the quantity. If liquid with a free surface is added to compartments high up in the ship (during firefighting, for example) it will have a more adverse effect on the ship's stability than if it were added low down, because it will combine the bad effects of free surface and top-weight.

Sub-division of free-surface liquids

If the same tank be fitted with a middle-line bulkhead (fig. 1–16) the centre of gravity of the liquid in it will not move so far from the middle line when the

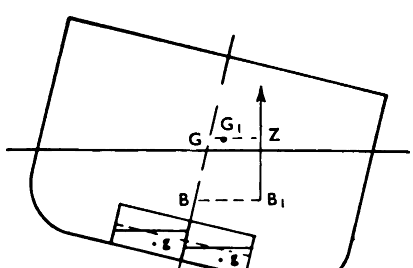


FIG. 1–16. Sub-division of free-surface liquid

ship heels or rolls, because the two smaller volumes of the liquid will move through shorter distances; the loss of righting lever and stability will, therefore, not then be so great. For this reason longitudinal bulkheads may be fitted in fuel and water tanks to break up the free surface and so reduce its effect on the ship's stability.

Dwarf bulkheads and sills. For the same reason longitudinal and transverse dwarf bulkheads, and sills in doorways, are built to a height of 21 inches on decks near the level of the waterline. Their function is two fold—to prevent the spread of shallow flood-water over these decks and so restrict loss of stability from free-surface effect; and, if a whole area *is* covered, to break up the free surface and thus reduce the effect, as shown above.

Correction of list

Unless caused by damage, list is usually easy to correct. All that is required is to balance the ship and so bring the centre of gravity back to the middle line. There are three ways of doing this:

1. by removing the off-centre loading, or an equivalent weight on the low side,
2. by adding an equivalent weight on the high side,
3. by shifting weights from the low side to the high side.

For a damaged ship with off-centre flooding causing a list (that is, generally, a large ship) the first method is usually impracticable because flood-water cannot be removed from compartments which are open to the sea, and the weight of this water is so great that there is nothing that can be removed from the low side heavy enough to compensate it.

The second method usually affords the quickest way to correct list, because in big ships the equivalent weight can be added by admitting sea water to wing compartments on the high side as counterflooding. In such ships, valves are usually fitted low down in wing watertight compartments so that they can be flooded direct from the sea.

The third method is theoretically the best because it avoids the increase of the ship's displacement produced by the second method. In practice, however, it usually means transferring fuel or other liquids across the ship, which is a slow process and not suited to the rapid correction of list. However, when the heel has been sufficiently reduced by counterflooding, pumping across of liquids is undertaken and, concurrently, pumping out counterflood water.

List caused by flooding is unusual in destroyers and smaller ships, because there is little or no longitudinal subdivision.

LOLL

The term *loll* describes the state of a ship which is unstable when in an upright position and therefore floats at an angle of heel to one side or the other. If disturbed by some external force, caused by wind or waves, the vessel will lurch to the same angle of loll on the opposite side. Loll is quite different from list, being caused by different circumstances and requiring different counter-measures to correct it, and it is therefore most important that the seaman should be able to distinguish between the two.

Loll may be caused either by a large area (especially breadth) of free-surface water inside the hull or by a large addition of top-weight; the following example shows how it may be caused by free-surface water.

In the description of free surface it was shown that an effect of free-surface liquid was to reduce the righting lever by shifting G towards Z. The greater the extent of flooding by free-surface water the further will G move away from the middle line when the ship heels. Consider a destroyer with three flooded main compartments extending right across the ship. If the ship heels to starboard, for example, as shown in an exaggerated form in fig. 1–17, the water in the flooded

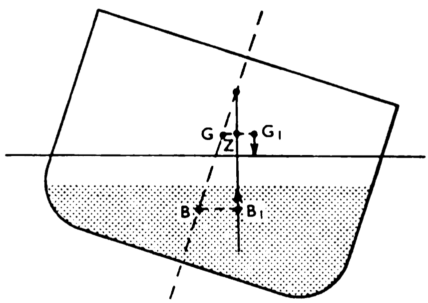


FIG. 1-17

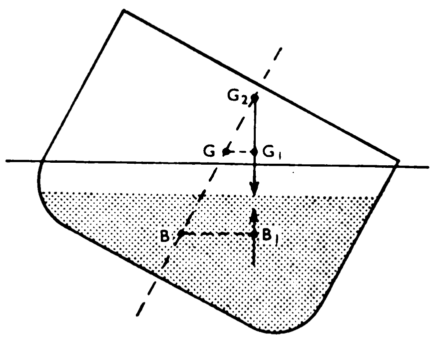


FIG. 1-18

compartments will run across to starboard and shift G so far that it may well pass beyond B_1 to the position G_1. The centre of gravity G_1 of the flooded ship is now beyond the centre of buoyancy B_1, and these two forces are tending to heel the ship still further over instead of returning her to the upright position. As the ship heels over further, however, the centre of buoyancy will also move further to starboard and the ship will come to rest at an angle of heel at which the centres of gravity and buoyancy, G_1 and B_1, are again in line, as shown in fig. 1–18. The cross-sectional shape of the hull determines the extent to which the centre of buoyancy can move, and if G_1 is still beyond B_1 when the latter has reached the limit of its travel, the ship will capsize. If, as a result of a change of course or of action by wind or waves, the ship heels over to port, the water in the flooded compartments will flow across the ship from starboard to port,

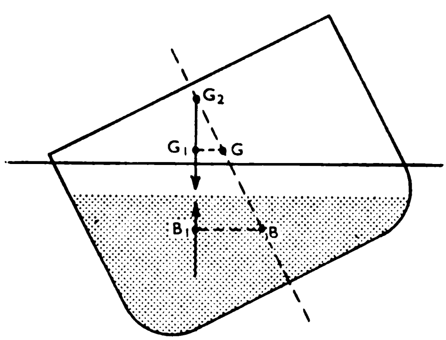


FIG. 1-19

and she will come to rest heeled to port at an angle equal to that of her previous heel to starboard (fig. 1–19).

An exactly similar effect would be caused by an excessive amount of top-weight being placed in the ship, thereby raising the centre of gravity to a dangerous extent. This is illustrated in figs. 1–18 and 1–19, in which G_2 represents the raised centre of gravity caused by top-weight. It will be seen that the vertical line of action of the force exerted by the weight of the ship passes through both G_2 and G_1. In this case the centre of gravity is fixed and does not move from one side to the other with the heel of the ship, but the effect is the same as that caused by free-surface liquid.

In each case the ship is unstable when upright and also when heeled to port or starboard up to the angle where B and G are in the same vertical plane.

Reduction of loll

There are four methods of reducing loll:

1. by removing weights from high up in the ship,
2. by reducing the area, especially the breadth, of free-surface liquid,
3. by adding weight low down in the ship,
4. by shifting weights from high in the ship to lower levels.

The choice of method or methods to be used depends upon the causes of the loll and the means available in the ship for correcting it. The first method is probably the most practicable, especially in small ships, and produces a double improvement because it lightens the ship, and thus increases her reserve of buoyancy, and it also lowers her centre of gravity. It is effected by jettisoning movable gear from the upper decks, but care must be taken to do this evenly each side of the middle line and not to jettison damage control, firefighting or lifesaving equipment, or ready-use ammunition if further attack seems probable. Lists of suitable equipment should be prepared in the order in which they may be jettisoned, so that this method may be effected quickly and correctly should the need ever arise. Such items as boats, torpedoes and anchors may be included.

The second method may be effected by plugging leaks and pumping out water; draining to lower and, if possible, narrower compartments; using transverse dwarf bulkheads—which may be quite temporary arrangements—to break up the free-surface area; or by completely emptying (or filling) tanks which contain liquid, according to whether they are high or low in the ship.

The third method may be effected by flooding compartments or tanks low down in the ship to their full capacity and thus ballasting the ship. It is effective in lowering the centre of gravity, but has the disadvantage of loading the ship still further and thereby reducing her reserve of buoyancy. If this method is employed the flooding must be carried out evenly each side of the middle line of the ship to avoid introducing a list in addition to the existing loll.

The fourth method is usually impracticable because movable objects small enough to be lowered through hatches are not usually of sufficient weight appreciably to affect the centre of gravity, and even if they were sufficiently heavy they would then be difficult to shift, particularly if the ship was lolling to a large angle.

EFFECT OF HEEL AND TRIM ON FIGHTING EFFICIENCY

Heel. Excessive heel from any cause will reduce the fighting efficiency of the ship in a number of ways, of which the following are examples:

1. It is difficult for men to get about the ship and carry out their duties properly when the ship is heeled.
2. Heel may restrict the fire of the ship's armament and decrease its accuracy by causing blind arcs of fire at angles of depression over the high side and increasing the effort required to train the directors, control instruments, guns, rocket-projectors and torpedo-tubes. Six degrees is about the largest angle of heel at which a ship's armament can be effectively fought.
3. Speed and manoeuvrability are reduced by heel.
4. The efficiency of some machinery, such as fixed pumps and feed regulators which depend for their operation on the maintenance of a steady liquid level, is reduced if the ship is much heeled.
5. In aircraft carriers the aircraft cannot be operated with full efficiency if the ship is heeled more than about two degrees.

Trim. Trim does not have any appreciable effect on fighting efficiency or stability unless it is so large that the freeboard at the low end is so little that the seaworthiness of the ship is endangered, or the forecastle or quarterdeck is under water.

CHAPTER 2

Firefighting Methods

Chapter 5 of Volume I gives a general description of the causes of fire, principles of extinction, portable hand firefighting equipment in H.M. ships and layout of the salt water main. This chapter deals with the organisation for preventing and detecting fires, the directing of firefighting, additional hazards in ships, mobile firefighting equipment and the remaining fixed installations.

ORGANISATION

Fire parties

A duty fire party must always be detailed and be ready to answer a call immediately by night or day, and an officer must be detailed to take charge of operations. The party should, if possible, consist of the following:

a chief petty officer or petty officer,
from four to six seamen or engineering mechanics,
one or two electrical ratings, for rigging temporary leads, etc.,
an engine room artificer or petty officer engineering mechanic, for magazine flooding or spraying,
a shipwright artificer.

This party is considered large enough to deal with any medium-sized outbreak of fire, but it may have to be augmented considerably if large-scale operations become necessary. A reserve of men should back up the fire party, but too many men in the fire area may result in overcrowding and chaos. Strict control of the men is vital, because there is a tendency in such circumstances for men to display misplaced gallantry or take undue risks, which often result in casualties and a complication of the issue.

When mustering and detailing the fire party before they take over duty, ensure that every man knows his duties. In all ships certain firefighting equipment such as protective clothing, adaptors and portable lamps is stowed at positions known as *fire posts*. The fire party is mustered at one of these when the alarm is given; each man is specifically detailed to provide certain items of equipment, and he then goes to the fire. This arrangement ensures that the fire party arrives at the fire with adequate gear to start operations, and that the normal outfit of equipment is not disturbed unless operations are prolonged.

Fire patrols

Organisation of patrols for the regular inspection of all parts of the ship is most important, particularly at sea in war and when the ship is in dock or refitting. Men detailed as patrols should be highly trained in firefighting so that they deal correctly in its early stages with any fire they discover.

Training

Exercises in as realistic a form as possible should be carried out frequently on board ships. It is Navy Department policy that everyone should do a fire-fighting course and that the course should be repeated at intervals.

Maintenance and stowage of equipment

The equipment must be maintained in a state of instant readiness, otherwise valuable time may be lost when fire occurs. After use, whether for exercise or at a fire, the equipment must be serviced, recharged, and replaced ready for use.

The correct stowage of firefighting equipment is of great importance in ensuring an immediate and continued supply at the scene of a fire. Equipment must be well distributed throughout the ship to allow for loss or inaccessibility through fire or damage; it must also be in positions where it is always accessible and where its stowage is easily memorised, to facilitate finding it in darkness and adverse conditions.

The type and amount of equipment in any part of the ship are governed by the nature and degree of the fire risk in the area or compartment. In addition, equipment is distributed about the ship for general use in messdecks, passages and flats and at fire posts. Extinguishers provided for compartments containing particular risks (for example, galleys, gasoline compartments, radar offices, switchboards) should be stowed inside the compartment, near to the main access but not where they would be hidden by the door when open; if the compartment is very congested the extinguisher should be outside but always near to the door. Foam extinguishers for firing spaces of boiler rooms should be on the floor plates and readily accessible to watchkeepers. Hand equipment supplied for general use should be stowed on the deck principally used for traffic and alongside bulkheads near watertight doors.

Stowage and treatment of inflammable materials

The use of inflammable materials in the structure and fittings of ships has been reduced to the minimum consistent with a reasonable standard of habitability, and special arrangements have been made for the stowage of highly inflammable liquids and materials. Much that is essential for personal use or comfort, however, such as clothing, bedding, curtains, oilskins and towels, is still a grave fire and smoke risk. The ship's organisation must therefore allow for such articles to be stowed away, or rolled up in bundles, and damped down when action is imminent.

Rendering materials fire-resistant. There is no known permanent method by which a material can be rendered fire-resistant without adversely affecting its texture. Textiles, however, can be made reasonably fire-resistant by treating them with a solution of ten ounces of borax, eight ounces of boric acid and one gallon of water. Articles should be immersed in the solution for about one hour, then be very lightly wrung out and laid flat to dry. Retreatment is necessary every six months, and on every occasion after wetting.

Handling and stowage of explosives. The precautions concerning the handling and stowage of explosives are clearly laid down in B.R. 862, *Naval Magazine and Explosives Regulations*. These regulations must be brought to the notice of all on board and rigidly enforced.

Reduction of paint. The coats of paint on bulkheads should not normally exceed two or at the most three; otherwise the spread of fire from one compartment to another is likely to be facilitated.

DIRECTION OF OPERATIONS

The first measures for dealing with a fire are taken by the man who discovers it; and usually, if it is attacked quickly and correctly, major measures are not necessary. If the fire is large, or develops quickly, operations must be directed by a responsible officer or senior rating, who must assess the situation thoroughly, control all firefighters and order the methods to be employed.

The duties of the officer in charge are to move about the fire area and keep himself informed of the situation as a whole; to make sure that the fire is not spreading; to look for possible complications and take precautions against them; and to instigate every action possible to ensure the safety of the firefighters. He should not take any active part in the firefighting himself.

A control point should be established as soon as possible, and for this purpose it is recommended that in a big ship the nearest NBCD Section Base is probably the most useful, because it has ample telephonic communication, is supplied with plans of the ship and is in direct communication with NBCD Headquarters, which should be kept informed of all developments and progress. In a small ship, a position should be chosen where telephone communication can be maintained with the O.O.W. or NBCD Headquarters, whichever is in control at the time. If the fire is a major one, the requirements of materials and personnel will almost certainly best be met by assuming NBCD State 1, in which case H.Q.1 will be manned.

Although speed is essential in the first attack on a fire, if the first simple measures fail a careful summing up of the situation is at least as important. The officer in charge, having thoroughly assessed the situation, will then be in a position to choose the most suitable technique and call for the necessary appliances.

Important questions at a major fire

The following questions give an indication of the matters which must be considered at a major fire, and when an officer or key rating takes charge he must immediately deal with them.

1. What is burning ?
2. Where is the seat of the fire ?
3. How can access be obtained ?
4. What appliances are needed ?
5. Is sufficient water available from the salt water main ?
6. What is threatened ?
7. What precautions must be taken to prevent the fire spreading ?
8. How can the construction of the ship be used to aid the extinction, or prevent the spread, of the fire ? Where should the fire boundaries be established ?

From these broad considerations the following, more detailed, questions arise:

9. Has NBCD Headquarters been informed ?

10. What dangerous gases or vapours, if any, are likely to be present? Is breathing apparatus necessary?
11. Is it necessary to spray adjacent bulkheads?
12. Is it necessary to remove inflammable materials from contact with bulkheads or decks?
13. Is it likely that spraying or flooding of a magazine or other dangerous compartment will be necessary? Are the flooding keys at hand? Is there a responsible rating present to carry out the spraying or flooding?
14. Is smoke travelling in such a way as to give a false impression of the position of the seat of the fire?
15. Is it advisable to close down the compartment and keep it closed down? Have ventilating fans been stopped? Is it necessary to close the ventilating trunks?
16. Are additional appliances required from other parts of the ship?
17. Are additional pumps required on the salt water main?
18. Are additional hands required? Can they be mustered quickly and easily?
19. Is the stability of the ship threatened? Has provision been made for pumping out excess water?
20. Should any electrical circuits be broken?
21. Are there any high-voltage electrical circuits in the fire area? Is there wireless, radar or sonar apparatus in the vicinity?
22. Would a change in the ship's course assist the firefighting operations? Does the fire situation warrant such a request?

When the fire is under control

1. Is it expedient to open up compartments for inspection?
2. Is it safe to ventilate the compartment with the object of clearing the smoke?

When the fire appears to be out

1. Is the fire really out? Are any materials still smouldering?
2. What steps should be taken to prevent reignition?
3. What damage has been done to electrical apparatus? What precautions are advisable in this respect?

Access to the fire

In a ship, approach to a fire from the most favourable angle is seldom possible. Most compartments below the waterline can only be entered from above, and this access will probably be the only outlet for the smoke and fumes. Fighting fires caused by enemy action may be complicated by jammed doors and hatches and twisted structure, and great care must be taken in approaching a fire in these circumstances. Damaged bulkheads and decks, however, often allow access to a fire from a more favourable angle than would otherwise be possible.

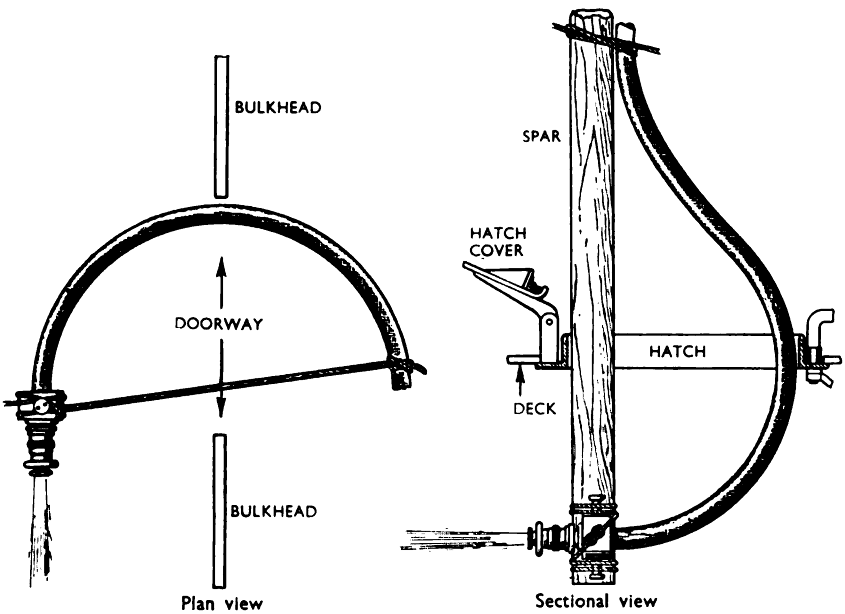
Broadly speaking, a fire may be assumed to be accessible if branch pipes can be directed to its seat through hatchways, doors or other openings.

Improvisation

No two fires are identical and therefore no rules of procedure can be laid down. Improvised methods of reaching the seat of the fire are often necessary, and

their nature will depend upon the prevailing conditions. The following are some examples of improvisation.

1. Fig. 2–1 shows two methods of directing water on to the seat of a fire which is otherwise inaccessible.
2. Cutting a hole in a bulkhead or deck through which to insert a branchpipe may be justified, but the advantages to be gained must be weighed against the loss of watertight integrity, and this expedient should be avoided and the main bulkheads and decks kept intact, if possible.
3. Lowering a man over the side to direct a branchpipe through an open scuttle, or a hole made by a shell or splinters, has proved effective.
4. Portable pumps may be used to boost the salt water main pressure high up in the ship if damage has reduced it.
5. The bulkhead emergency connections should be used to run lengths of firehose through the ship, thus enabling watertight doors to be kept closed.



(i) Method of rigging a hose through a doorway to direct the water-jet to the side of an adjacent compartment. (ii) Method of rigging a hose through a hatch to direct the water-jet to the side of the compartment below.

FIG. 2–1. Methods of rigging hoses

Stability and firefighting

The effect in firefighting of the extensive use of water on the stability of the ship is not generally realised and is likely to be overlooked at the scene of a fire. As further damage in other parts of the ship may render stability critical if more water is added during firefighting, it is essential to maintain a close liaison with NBCD Headquarters and to consult them before any major flooding is undertaken. NBCD Headquarters must remain the overriding authority on all damage countermeasures, and it may be in a position to dictate the firefighting technique to be adopted.

When firefighting, *all* water added to, and remaining in, the ship increases draught and so reduces freeboard and reserve buoyancy. The following points must be borne in mind in relation to stability:

1. Water in an outer compartment of the ship will result in unsymmetrical loading and cause a list. This applies generally to cruisers and larger ships only.
2. Water in a compartment high up in the ship will add top-weight and reduce stability.
3. Partially flooding a compartment will create a free-surface effect. Whether situated centrally or to one side, there will be a virtual reduction in initial stability, roughly proportional to the length multiplied by the *cube* of the breadth of the compartment.
4. Completely flooding a compartment low in the ship increases the righting forces, but a free surface is created while the compartment is filling.
5. Loose water in a compartment must be removed as soon as possible.
6. When water from a flooded compartment is used for firefighting, the mean draught of the ship will not be affected, but a change in the loading of the ship will result. A free-surface effect will also be created, both in the compartment from which water is being drawn and in that to which it is being pumped. There is also a grave risk that such water may be contaminated with fuel. The operation must therefore not be undertaken without due consideration of these factors.

The effects of loading and of free-surface water on stability are described in Chapter 1.

Estimation of the quantity of water being used

It is essential that a close check of the quantity of water being used should be kept, for the following reasons:

1. To enable NBCD Headquarters to assess its effect on the stability of the ship.
2. To equate it to the output of the pumps connected to the salt water main, and to ensure that the salt water main pressure available is adequate to operate the appliances efficiently.

The capacity of the pumps supplying the salt water main is quoted in tons per hour. In the older ships, the dual-purpose pumps have an output at full speed of about 50 tons per hour each in a destroyer and 75 tons in a larger ship. In modern ships, the fixed fire pumps are single-purpose pumps of 150 tons per hour. It must be remembered that although the pressure in the salt water main, as supplied by the pumps, may be 100 lb per sq. in. when no equipment is being used, the actual pressure at a nozzle will be considerably less, depending on how far it is from the pumps and how many calls are being made on the main.

The table overleaf shows the quantities of water, in tons per hour, discharged by various branchpipes at different pressures. If, for example, on one isolated section of the salt water main supplied by one 75-ton pump four jet/spray nozzles are in use at only 35 lb/sq. in. nozzle pressure, two as jets and two on maximum spray, the total output capacity of the nozzles would be 77½ tons per hour. In this case it would be necessary to deisolate the salt water main—that is, to bring another section of the salt water main and more pumping

BRANCHPIPE NOZZLE PRESSURES AND DISCHARGE RATES

PRESSURE AT NOZZLE (lb/sq. in.)	WATER BRANCHPIPES							FOAM BRANCHPIPES				
	JET/SPRAY			SPRAY/JET			OILFYRE					
	Max. Spray 110°	Spray 90°	Jet	Max. Spray 45°	Spray 90°	Jet	Spray	F.B. 2(P)	F.B. 2(S)	F.B. 5(X)	F.B. 10(P)	F.B. 10(X)
35	23½	22½	15¼	8¼	5¼	9½	15½	8½	14	9	20	22
50	28¼	27	18	10	6¼	11¼	18½	9½	16¾	10¼	23½	26½
65	32	30¼	20¾	11¼	7¼	13	21	11	18¾	12	27	30
80	35¾	33½	23¼	12½	8	14½	22¾	12½	20¾	13¼	30	33½
100	39¾	37¼	26	14	9¼	16	25	13½	23	14¾	33½	37½
120	43¾	41½	28¼	15½	10	17½	27	14¾	25	16¼	37¼	40½

capacity into use—otherwise the nozzle pressure will drop below 35 lb/sq. in., which is the minimum pressure at which the appliances will work effectively. Spray/jet nozzles discharge very much less water than jet/sprays; they are used for general firefighting purposes in ships, but some jet/sprays are carried at the fire posts and on the flight deck of a carrier for thoroughly wetting masses of smouldering material or for use in firefighting against a strong wind.

Reignition

The dangers of using more water than is absolutely necessary have been stressed, but there is also the danger that unless the fire is completely extinguished and the vicinity cooled it may light up again. It is therefore essential that when the fire appears to be out a thorough inspection be made to ensure that no smouldering materials remain. Similarly, when an oil fire has been extinguished by using foam, the foam blanket must remain intact until the oil has cooled down, and particular care must be taken when the ship is rolling that the foam blanket does not break at the edges or around bilge obstructions, as this might allow the fire to reignite.

ADDITIONAL FIREFIGHTING HAZARDS IN SHIPS

Dealing with a fire involving any one material in a single space is straightforward, but, owing to the complex nature of a ship's equipment, there will always be additional hazards to complicate firefighting operations. Some of these hazards are described in the following paragraphs.

Changes in electrical loading

The insulating material of electrical systems in the fire area may be charred through, causing shorting and hence changes in the loading of circuits. Patrols must therefore be organised to inspect spaces remote from the fire area and to watch for subsidiary fires in electrical systems, for some time after a fire has been extinguished.

Liquid fuels

Serious complications can arise when there are liquid fuels near a fire, and a knowledge of how they can be ignited is essential for a correct assessment of the risk involved. The following principles apply to all inflammable liquids; more information on the subject can be found in B.R.3000, *Marine Engineering Manual*.

Before a liquid fuel can be ignited it must produce enough vapour to form an inflammable mixture with air. Gasoline and some other highly inflammable liquids will produce enough vapour at ordinary temperatures (even at temperatures below zero in the case of gasoline) to allow ignition to take place when a spark or flame is applied. Furnace fuel oil, though less volatile than gasoline, may also produce an inflammable concentration at ordinary temperatures, particularly in hot weather and in the tropics.

A mixture of fuel vapour and air is inflammable only when the proportions are within certain limits, known as the *limits of inflammability*, which are

generally expressed in percentages by volume of vapour to air. For gasoline these limits are from 1·4 to 7·5 per cent (i.e. about 98 to 92 per cent air). This means that one gallon of gasoline, which will form about 25 cubic feet of pure vapour under normal conditions, when diffused into the air can produce about 2,000 cubic feet of inflammable mixture. The mixture will not be uniform. Gasoline vapour is heavier than air, so that most of the vapour will remain near the surface of the liquid and will even pour down through openings into lower spaces. However, vapour also diffuses upwards and outwards, so that near the liquid there is bound to be some part of the mixture in the right proportions to ignite; this is illustrated in fig. 2–2. If ignited, this part of the mixture *flashes* and, in the turbulent conditions set up, more vapour and air can mix and burn almost instantly. When gasoline or a similar volatile fuel is exposed in a compartment or on the weather deck, it is not possible to say, without elaborate apparatus, which parts of the mixture are within the limits of inflammability.

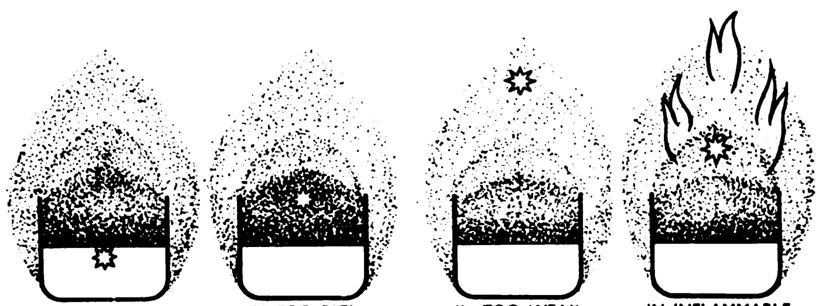


FIG. 2–2. How gasoline vapour ignites

They may be high or low in a compartment, in an adjacent compartment, on a deck above or below, or many yards away from the liquid. Thus a distant spark, flame or hot surface may cause a long *flash-back* to the liquid. In this context there is no simple distinction between a flash and an explosion. It is simply a matter of flame velocity and pressure.

Furnace fuel oil and dieso are not so dangerous as gasoline, but it must never be assumed that an explosive mixture does not exist above the liquid surface in a tank containing these fuels, even when the atmospheric temperature is below the flash-point of the fuel. With the restricted air supply, the vapour may build up to the lower limit of inflammability and the lighter fractions of the fuel may allow of a flash at a quite low temperature. The danger, however, is more one of explosion than of burning. If the boundaries cannot be adequately cooled, it may be necessary to fill the tank with water.

A further possibility is that the seams of a fuel tank may open up and so allow oil to leak into the fire area; should this occur the tank must be emptied. Provided that leakage has not occurred, it is preferable to fill the tank to 95 per cent of its capacity and then top it up with water if necessary, thus avoiding structural damage due to heat. The effect of such action on the heel and trim of the ship must, of course, be considered.

Explosives and fireworks

Explosives and fireworks of all kinds present a serious complication when fire occurs in a ship. Fixed installations are provided for protecting magazines and certain other spaces where explosives or highly inflammable stores are stowed. In addition, there are water drenching systems to protect cordite charges at positions associated with magazines and gun mountings.

Ready-use ammunition lockers containing cased ammunition, which are not fitted with flooding and spraying arrangements, should be cooled with branch-pipes if there is any danger of their becoming heated from an adjacent fire.

Gas cylinders

All cylinders containing compressed gases must be considered as being highly dangerous if near a fire. They should be removed from the fire zone, or, if this is impossible, they should be kept cool by water-spray to prevent them from bursting when their contents expand in the heat from the fire.

High test peroxide (H.T.P.)

This is a highly concentrated solution of peroxide of hydrogen. It is not inflammable, but, because it liberates oxygen in large quantities, it is a formidable supporter of combustion. Contact with even traces of impurities will cause it to decompose and, if decomposition is rapid, produce considerable heat. It can cause spontaneous combustion (see page 27) in many materials, either immediately or up to a considerable time after the material is wetted with H.T.P. It may be met with in ships, and any fires involving it should be dealt with by using large quantities of water, fresh or salt, to cool and dilute the H.T.P. *Foam should not be used.* H.T.P. oxidizes organic materials and therefore P.V.C. overalls and gloves should be worn when working with it.

Dangerous gases

When a fire is burning in a confined space and the supply of air is therefore limited, combustion will be incomplete and carbon monoxide (CO), an odourless and highly toxic gas, will be produced; this gas is also present in the exhaust from internal combustion engines. When plenty of air is available, combustion will be more or less complete and carbon dioxide (CO_2) will be formed. This is not poisonous, but will not maintain life.

Lack of oxygen in the vicinity of a fire is another complication. Not only is oxygen consumed by the burning of the fuel, but the carbon dioxide and water vapour produced in the combustion displace much of the remaining oxygen, which means that the air near a fire may be completely vitiated. The state of the fire is a useful guide to the condition of the surrounding air. If it is burning freely with little smoke, there should be ample oxygen in the vicinity. If it is burning fitfully with much smoke, there is little oxygen but probably a high concentration of CO_2 and perhaps CO.

Some of the substances used in firefighting add to the toxic risks. Carbon monoxide and dioxide have already been mentioned. Methyl bromide, which has been used in the fixed firefighting installations of gasoline-engined small craft (see page 31) is highly toxic; it is being replaced by CB/Freon, which is

much less toxic but demands the same care as is required in using methyl bromide (the precautions are, in fact, the same). The vapour of carbon tetrachloride (C.T.C.) (see page 33) is also toxic. When either C.T.C. or methyl bromide is used on a fire the products of combustion are also highly dangerous—C.T.C. gives off phosgene, a lethal gas.

A further danger arises if it is necessary, when firefighting, to enter compartments which have been shut for some time. Paint coatings absorb oxygen and the air may be vitiated. This condition can also obtain after an explosion, which may have consumed all the oxygen in a compartment.

From all of the above it will be seen that stringent precautions are required to avoid unnecessary casualties from these causes. A casualty in the fire area means that several men may be engaged in rescue work when they can least be spared from firefighting.

Breathing apparatus must be worn if there is the slightest doubt as to the condition of the atmosphere for breathing. The types available are described on page 37. It is once more emphasized that the Service anti-gas respirator gives no protection against carbon dioxide or carbon monoxide, and it is useless where oxygen is lacking. It gives only limited protection against methyl bromide, C.T.C., gasoline fumes or smoke, but may be used in emergency in these conditions for escape purposes only.

POTENTIAL CAUSES OR SOURCES OF FIRE

Seepage of inflammable liquids and vapours

Highly inflammable liquids and their vapours are extremely liable to seepage, and bulkheads and pipe-joints which are normally watertight may allow such liquids or vapours to seep past or through them. Therefore before any work involving sparks or heat is undertaken care must be taken to ensure that no dangerous vapours are present in spaces near gasoline systems.

Static electricity

Many fires have been started by a spark caused by the discharge of high-potential electricity generated by friction in the filling hose during the delivery of gasoline; others have been caused by the different electrical potentials of the supplying and receiving vessels. To avoid this danger arising when gasoline is being transferred by hose, the hose end and the tank which is being filled must be bonded or earthed, so that any charge generated will be dissipated harmlessly.

Wireless, radar and lightning

Transmission on ship's wireless and radar sets is liable to induce electric currents at voltages which may be a source of danger during the embarkation and handling of inflammable stores and liquids, e.g. when aircraft are being fuelled. When such work is being carried out no transmission is to be allowed on radar sets, and transmission is only to be permitted on wireless transmitters which have a rated output of 50 watts or less. For the same reason handling of highly inflammable materials must be suspended during a thunderstorm.

Spontaneous combustion

When materials made from vegetable fibre (e.g. cotton) are oily, the chemical action of the oil on the material generates heat which, if it cannot be dissipated, will eventually cause the material to burst into flame. This is known as 'spontaneous combustion'. The process is accelerated under hot conditions such as obtain near a steam pipe or an electric radiator.

Rags used for mopping up oil are the most common sources of this fire hazard, and such materials must be disposed of safely and quickly. Bagged foodstuffs, painted canvas and charred wood are other examples of materials liable to spontaneous combustion.

Welding and burning

Welding and burning are employed extensively in the building and repair of ships, and the sparks given off when this work is in progress—also the heating of the plates involved—constitute a serious fire risk. Fire extinguishers must be ready, and a watch must be kept on the other side of the deck or bulkhead being welded or burnt to ensure that a fire does not start there.

Any space in which welding or burning has been carried out, and all spaces adjacent to it, should be carefully patrolled after work has ceased in order to make sure that no smouldering materials remain. Regulations regarding welding and burning operations are given in B.R.3000, *Marine Engineering Manual.*

Harbour risks

Extra vigilance in fire precautions is necessary when a ship is in a dockyard or a port, because refitting work is then frequently in progress and a proportion of the ship's pumps may then be under repair. Fire in a ship in harbour may endanger other ships or nearby shore installations. Shore fire services, however, are readily available and, whether assistance is required or not, the dockyard authorities must be informed immediately a fire is discovered.

Floating oil or gasoline. An additional fire risk, sometimes present in harbours or basins, is oil or gasoline floating on the water; if ignited, this will endanger all ships in the vicinity. A layer of burning liquid can be driven with water jets to some position where it will do no harm, and there be extinguished with spray or foam. Another useful method of driving burning liquid in the required direction is to use the wash of a ship's power boat, preferably diesel-driven.

Ships in dry dock. The danger of fire spreading in a ship in dry dock is increased because the hull of a ship is no longer cooled by the water in which she normally floats.

In accordance with B.R.862, *Naval Magazine and Explosive Regulations*, hoses must be rigged from all available dockyard hydrants and be connected to the ship's salt water main and to the flooding bonnets fitted over the sea inlets to the magazine flooding systems. In the event of a fire the demand for water may exceed the capacity of the water mains feeding the ship's hydrants, and the ship's portable emergency pumps should be kept ready to provide the additional water required from any nearby water supply.

FIREFIGHTING INSTALLATIONS

Magazine spraying

Spraying arrangements are fitted in virtually all magazines, handing rooms, rocket and bomb rooms and in some gun bays. A lead from the salt water main feeds a grid of pipes fitted with sprinkler heads, which produce a spray when the jets of water impinge on small discs with serrated edges. There are two types of sprinkler head—the open-ended type, in which case the grid system is empty until the spray valve is opened—or the quartzoid bulb type—in which case the spray valve is open and the system is filled with water up to the sprinkler heads. When the temperature in the vicinity of a quartzoid bulb reaches a certain level the bulb bursts and releases the water.

Two valves are fitted to the lead from the salt water main to the spray grid. One valve, called the isolating valve, is fitted close to the salt water main itself. The second valve, called the spray valve, is fitted near to the magazine. The

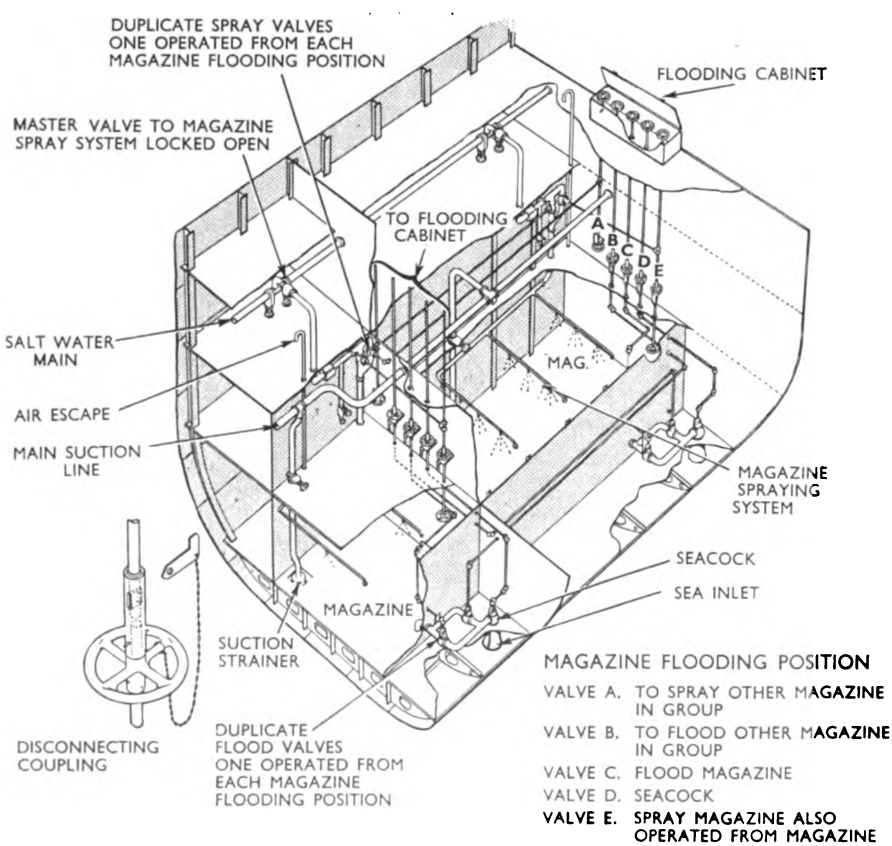


FIG. 2–3. Magazine flooding and spraying arrangements

isolating valve is normally locked open, and is only closed when the spray valve is opened for routine tests. The spray valve can be operated from three positions (fig. 2–3). With the quartzoid bulb sprinkler system both valves are kept open.

Spraying imposes a load on the salt water main, but is quick, effectively wets all the contents of the magazine without necessarily ruining them, and has little effect on stability.

Magazine flooding

In some ships where the magazines are below the waterline they are fitted with flooding arrangements in addition to spraying arrangements. The compartments are flooded direct from the sea through a seacock and a flood valve. Flood valves are generally operated from three positions in larger ships and two positions in small ships.

Flooding is a slow process and drastically increases displacement. Its advantage is that it is less easily affected by action damage or defect. It is generally fitted as a secondary means where both flooding and spraying can be accepted. When flooding is ordered, sprays must always be operated at the same time to obtain immediate protection, especially for the upper stowages.

Flooding cabinets. Flood and spray valves are grouped at the upper operating position in a flooding cabinet or flooding locker.

Drenching. Some propellant conveyors are fitted with salt water main-fed drenching arrangements.

Inflammable stores

Stores and compartments containing inflammable materials, liquids or gases (such as paint rooms, dope stores, spirit rooms, avgas control compartments, oxygen, acetylene and hydrogen stores) are in general fitted with manually-operated spraying arrangements. Certain compartments, e.g. those fitted to carry avpin, are fitted with both open-ended and quartzoid bulb sprinklers.

Hangar spraying

The hangars of aircraft carriers are fitted with quick-acting spraying arrangements which are operated from the hangar lobbies. Water is supplied to these sprays by special high-capacity pumps, which are started simultaneously when it is desired to spray the hangar. Hangars are sprayed in sections, but all sections of the hangar may be sprayed together if required.

When the spray is operated in a closed hangar so little air reaches the fire that it is smothered, and the fire is thus prevented from spreading. Hangars can be divided into sections and separated from the lift wells by asbestos curtains; these are lowered by hand, or by electric motors controlled from nearby lobbies.

Hangars are provided with large scuppers to drain away the water after spraying, ***and it is important always to keep these scuppers clear and to ensure that no inflammable liquids are poured down them.***

Steam smothering

Machinery spaces of some ships are fitted with steam smothering systems, operated from outside. It is essential that the compartment should be sealed as

effectively as possible before the steam is turned on. The compartment must be kept closed for some time after the steam has been shut off, to allow it to cool thoroughly and so avoid reignition.

Foam inlet tubes

Engine rooms, boiler rooms and certain other machinery compartments are fitted with tubes for supplying foam from the deck above. These tubes are arranged so that they direct the foam down to the bilges where it can flow over the surface of any burning liquid.

High-level foam sprinklers

In some new ships, particularly those with gas turbine machinery, a high-level foam sprinkler system (fig. 2-4) is fitted in the machinery spaces. A ring main supplies the sprinkler heads with a premixed solution of foam compound in water from the salt water main. This system has three main advantages over the foam tube arrangement: it is effective on fires above bilge level, it shields the deck head from intense heat, and it gives better and quicker coverage when the bilge has many subdivisions.

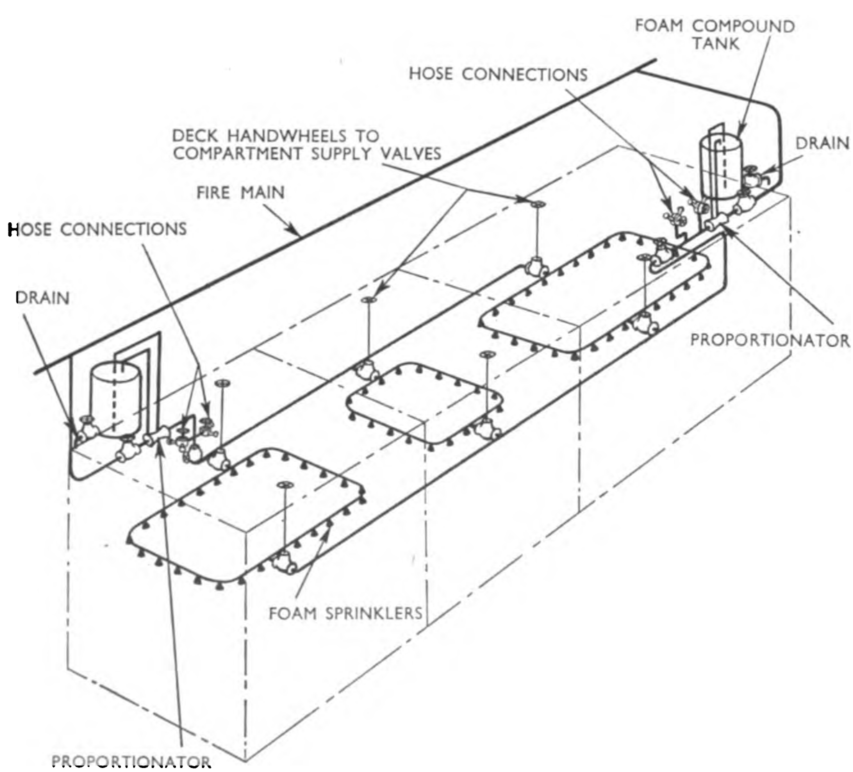


FIG. 2–4. High-level foam sprinkler system

Fixed foam installations for enclosed boiler casings

Foam installations are fitted in the boiler rooms of ships with enclosed boiler air casings. The system consists of one or more fixed foam generators having flanged pipe connections for salt water main supply and for discharge pipes leading to the boiler casings. A lead to the bilge, fitted with a plug-cock, branches from the discharge pipe. Each generator has a suction pick-up assembly which should be kept permanently secured to the connection on the generator.

The system is operated by opening the salt water main valve and the plug-cock in the bilge lead and inserting the end of the pick-up into a drum of foam compound. As soon as foam is seen to flow from the lead to bilge, the sluice valve fitted in the lead to the boiler casing should be opened and the plug-cock closed. The foam flows to a grid in the boiler air spaces, where it is distributed through spreaders to cover the whole floor space.

A fire hydrant is fitted on the discharge lead so that a hose can be connected and used, *without any branchpipes*, for spreading foam in the boiler room itself for firefighting. In this case great care must be taken to avoid kinks in the hose.

Gasoline-engined small craft

The engine rooms and tank compartments of gasoline-engined small craft are fitted with a gas discharge system for smothering fires. The gas is supplied from cylinders fitted in the engine room and near the tank compartment, and is released by operating gear in either of two positions, one on the bridge, the other near the hatch of the engine room, or near the cylinder for the tank compartment. Methyl bromide has been used in these systems and may still be found. The gas is poisonous to breathe and the liquid (and sometimes the vapour) can blister the exposed skin. When the gas has been released or has escaped, it must be assumed that it has diffused through the whole craft and, until it has been thoroughly ventilated for some hours, no one must go between decks unless wearing breathing apparatus. Any unprotected personnel who have been exposed to an atmosphere containing methyl bromide should be given medical attention at an early opportunity. Methyl bromide is being replaced by CB/Freon, which is much less toxic, but similar precautions should be observed.

Carbon dioxide installations

In diesel-driven ships the main machinery spaces are fitted with *one-shot* CO_2 smothering systems. The system consists of a battery of CO_2 cylinders in a stowage outside the machinery spaces. The gas is led from the cylinders through a pipeline to a system of outlet nozzles in each engine room. Once the system is operated, all the gas will be discharged and the cylinders will need replacement or recharging. A control position above each engine room contains the following:

1. a valve which will allow gas to be supplied to the engine room,
2. a pull-handle and bowden cable for operating the release mechanism at the cylinders,
3. a safety switch to operate an audible electric alarm in the machinery space.

MOBILE EQUIPMENT

Foam units

Foam was mentioned in the last section; it is sometimes called *mechanical* foam to distinguish it from the *chemical* foam of the hand extinguisher. It is a mixture of foam compound, water and air and is used for extinguishing liquid fuel fires. It is made in what are termed *main* foam appliances—designed to operate off the salt water main. Water under pressure passes through the central passage of the appliance and by means of a venturi effect draws foam compound from a container through an inductor hose. The small-bore inductor hose ends in a sharpened steel pick-up tube for piercing the container. The mixture of water and compound is aerated by air drawn into the appliance and the resulting foam is ejected at the end (fig. 2–5).

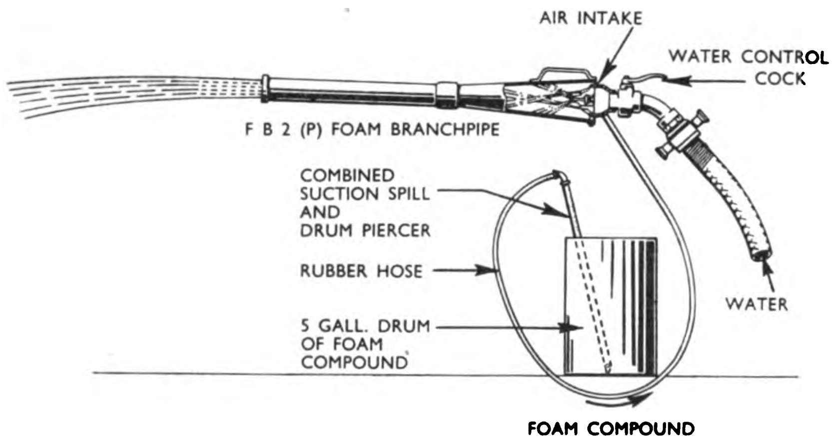


FIG. 2–5. Foam unit

In most of the appliances the complete operation is carried out in the foam branchpipe. These vary from a unit (F.B.(O)) which will work off a two-man manual pump using a knapsack tank of foam compound (fig. 2–6) to the lightweight F.B.5(X) for general use and the large F.B.10(P) used in the hangars and on the flight deck of carriers. In carriers with a separate 100 lb/sq. in. flight deck salt water main, a somewhat different arrangement is used for crash fires. An in-line inductor is supplied for each hydrant. It has a hose connection at each end and a connection for a pick-up assembly. Foam is induced into the water stream and the mixture is taken through a hose line to the fire. The delivery end is connected to a large-capacity lightweight branchpipe (F.B.10(X)) which aerates the foam. By this arrangement there is no need to carry drums of foam compound across the flight deck.

Foam units must be handled and stowed carefully; if they are damaged they will not work efficiently.

Mobile dry powder units

The P.D.150 dry powder unit is supplied for aircrew rescue work on the flight deck. It consists essentially of a tank containing chemical powder which

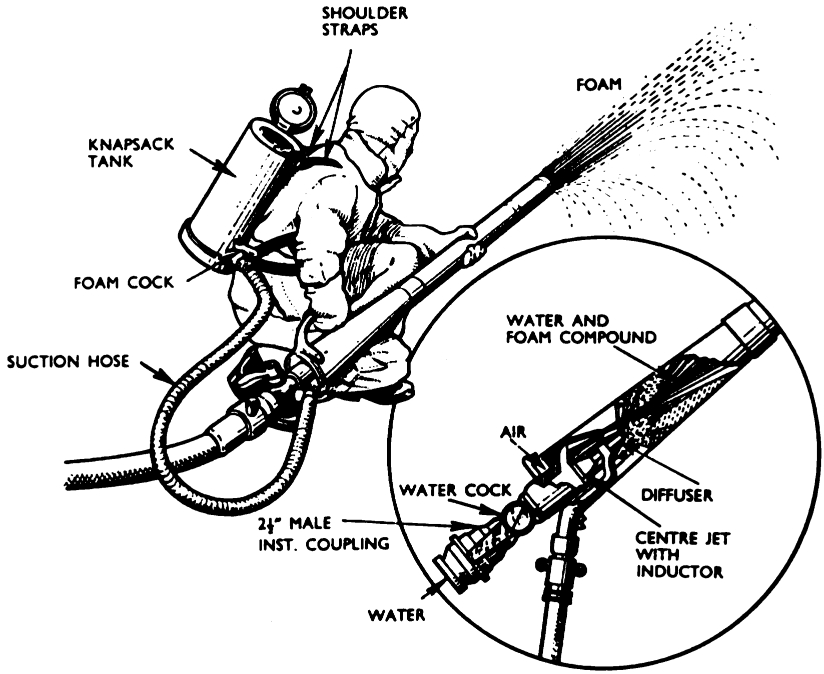


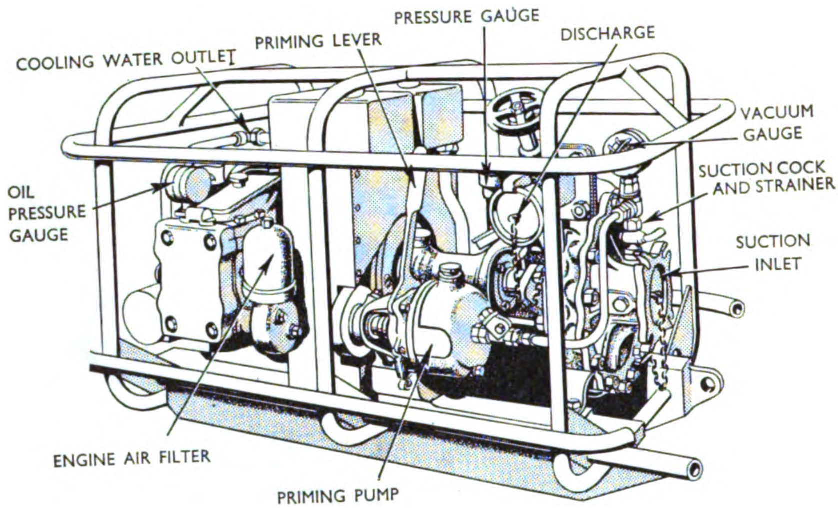
FIG. 2–6. Self-contained portable foam unit

can be expelled under pressure through a hose and nozzle. The pressure is supplied by a cylinder of CO_2 and the whole outfit is mounted on a trolley. The tank is pressurised by removing a safety pin and squeezing together two levers on the CO_2 cylinder. Then, on squeezing the nozzle discharge valve at the delivery end of the hose, the powder is ejected. Two men are required to operate the unit, one for the trolley and the other for the nozzle. The trolley must always be stowed horizontally.

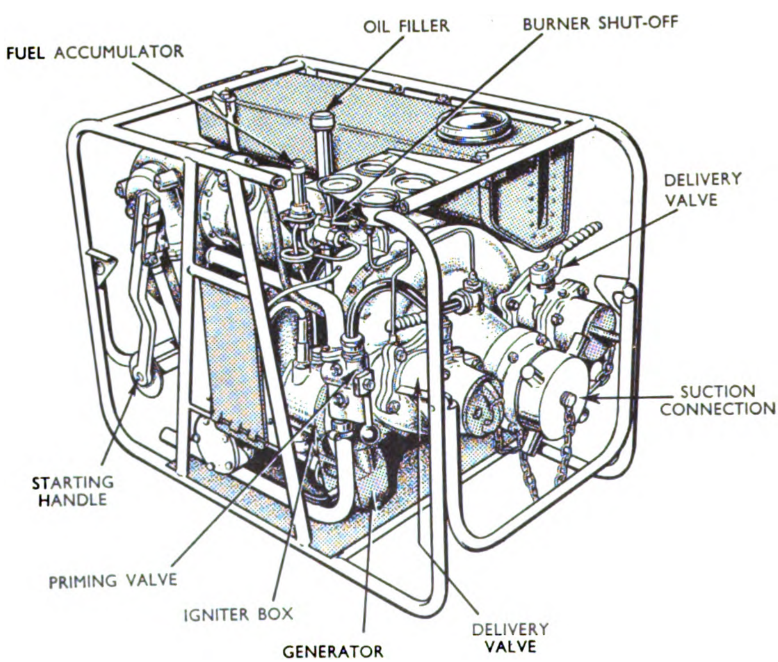
A smaller version of this type of extinguisher is the P.D.12, which is supplied for similar duty in connection with helicopters.

C.T.C. pressurised tank equipment

The C.T.C. pressurised knapsack tank equipment is supplied for dealing with starting up, carburettor and spill fires on the flight deck of a carrier, where there is plenty of fresh air. It consists of a steel cylinder containing, when charged, ¾ gallon of carbon tetrachloride with an ullage space which can be filled with air under pressure. The cylinder is fixed to a back plate and the whole is slung from the shoulders and secured to the body by a harness. At the base of the cylinder is a discharge valve and a discharge hose ending in an applicator with a hand-grip trigger mechanism. The applicator normally stows in a scabbard attached to the harness. When the tank has been charged with C.T.C. it is pressurised by connecting the low-pressure air line, or a foot pump, to the air-charging connection on top of the tank. The tank is charged to 80 lb/sq. in., pressure being checked with a tyre gauge. One man only is required to operate



(i)



(ii)

FIG. 2–7. (i) Diesel-driven portable pump; (ii) Rover gas turbine pump

the unit, but at least two units are held ready for use when flying operations are in progress. The applicator should be aimed toward the base of the fire. The unit has a maximum continuous discharge time of 2½–3 minutes.

As was stated earlier, C.T.C. fumes are highly toxic and the products of its combustion include the lethal gas phosgene. Great care must be used in handling the liquid.

PORTABLE EMERGENCY PUMPS

Portable firefighting pumps are carried in ships for backing up the salt water main or temporarily replacing a damaged part, and for limited firefighting ashore. Ships are supplied with diesel-driven or gas turbine pumps for this purpose.

Diesel-driven pump (fig. 2-7 (i))

The diesel-driven pump has a suction lift of up to 25 ft above the surface of the water supply. The output is nominally 27 tons per hour at discharge pressure of 50 lb/sq. in., but it must be remembered that the discharge head will reduce the effective discharge pressure and the output. The pump is not self-priming, that is, it will not deal with air or air and water. A small priming pump, built into the unit, is engaged by hand at the start of pumping operations and held in place until the main pump is sucking water. If the pump has to be used between decks a flexible extension exhaust hose, which is provided, must be connected and led to the open air. The pump must not be used between decks without this fitting.

These pumps have certain shortcomings for the work, particularly in small ships, and it is likely that they will be withdrawn and the ships supplied with either electric or gas turbine pumps for firefighting.

Rover gas turbine pump (fig. 2-7 (ii))

This pump has a suction lift of up to 25 ft and the output is about 77 tons per hour at a discharge pressure of 100 lb/sq. in. when the static lift is 10 ft.

Two-man manual pump (fig. 2-8)

Some small ships are provided with two-man manual pumps which are hand-operated, single-cylinder, double-acting, self-priming piston pumps. One type, when operated at 60 double strokes per minute with a suction lift of 10 ft, can produce a good jet through a quarter-inch nozzle at 30 lb/sq. in. The pump can be used with an F.B.(O) branchpipe for foam-making.

Electrically-driven salvage pump (fig. 2-9)

The electrically-driven 35 and 70 tons per hour pumps which are supplied for salvage work can be used for firefighting, although the present pumps are not so satisfactory as pumps designed for the purpose. They should operate within a limit of 20 ft above the waterline and then the 35-ton pump will support one, and the 70-ton pump two, jet/spray nozzles at a pressure of 20 to 25 lb/sq. in.

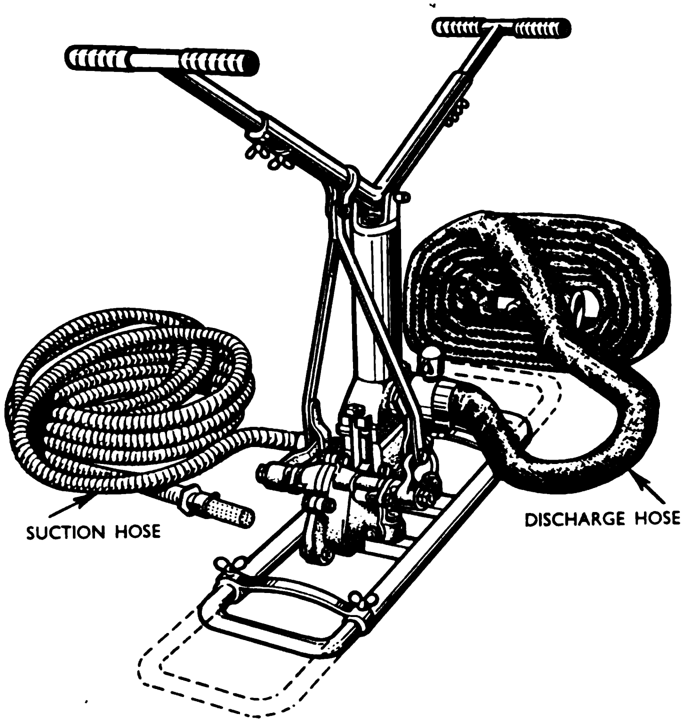


FIG. 2–8. Two-man manual pump

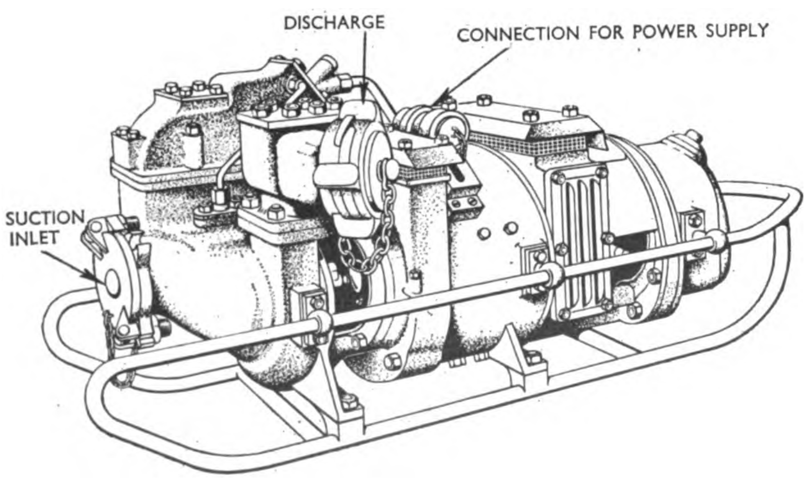


FIG. 2–9. 70-ton electrically-driven salvage pump

Internal standpipes for portable pump suction

To enable suction to be obtained from the sea when the ship is under way at speed, internal standpipes are provided before and abaft the main machinery spaces, and fitted with swing-bolt suction-hose connections to which the suction hose of a portable pump can be connected. Destroyers are fitted with two standpipes, and larger ships with four.

AUXILIARY FIREFIGHTING EQUIPMENT

Hand torches

These are provided in fire and damage control lockers for use in emergency; they must be maintained in good order and must not be used for any other purpose.

Headlamps

These battery-operated lamps are strapped to the forehead, thus leaving both hands free. The batteries must be recharged and tested frequently.

Floodlights

These are supplied for emergency lighting and can be connected to any supply box by a long, flexible lead. They should only be connected by electrical ratings.

Portable battery-operated floodlights

These are supplied for use when the normal ship's lighting has been put out of action. Their primary use is for providing lighting in the vicinity of a fire, or for repair operations while emergency lighting is being rigged. The lamp is similar to a car headlamp and is mounted with a swivel connection on the top of the battery case. The battery will give a strong light for several hours.

Fearnought suits, anti-flash hoods and gauntlets

These are provided in the fire lockers and should be worn for protection from heat when firefighting.

Breathing apparatus

Two kinds of breathing apparatus are supplied and stowed about the ship ready for use; they are the Salvus apparatus and the Smoke Mask, Pattern 5665. The Salvus apparatus is a self-contained breathing apparatus in which oxygen is supplied for inhaling and exhaled carbon dioxide is absorbed. It is used nowadays only for firefighting and will last for about three-quarters of an hour or more without recharging. A self-contained breathing apparatus using compressed air has been developed for damage control purposes and will replace the Salvus for firefighting duties.

The Smoke Mask, Pattern 5665, enables the wearer to receive fresh air through a flexible, fireproofed breathing pipe, supplied in 60- and 30-ft lengths which can be coupled together. At one end of the pipe is a face-piece incorporating an air valve; at the other end is a strainer. A harness is provided

to prevent the pipe from pulling on the facepiece when the wearer moves about. When the apparatus is in use, the strainer should be held or properly secured in the fresh air, clear of smoke and running water. Not more than 120 ft of hose should be used or breathing will become difficult.

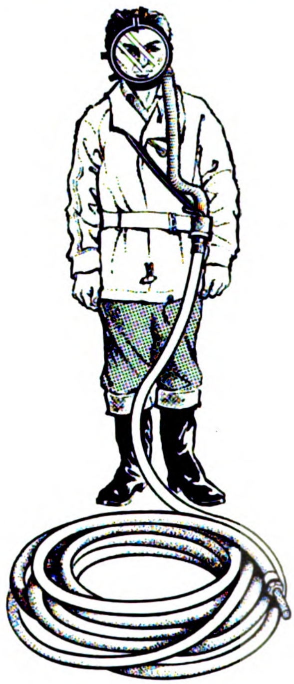


FIG. 2–10. Smoke mask, Patt. 5665

A lifeline should be worn with either type of breathing apparatus when it is of assistance to the wearer or when, in the opinion of the officer or rating in charge of the operation, it would be dangerous to proceed without one. Lifelines may be specially useful when rescue work is undertaken. Lifelines and hoses must be tended with great care or there may be grave danger to the wearers.

It is once more emphasized that the Service anti-gas respirator gives *no* protection against carbon dioxide or carbon monoxide, nor does it compensate for deficiency of oxygen. It gives *limited* (but only limited) protection against smoke, gasoline vapour, methyl bromide and the toxic products of C.T.C. Its use is likely to give a false sense of security to firefighters. It should therefore never be used for firefighting except as a means of escape in extreme emergency.

METHODS OF EXTINGUISHING FIRES

Methods of tackling different types of fires are briefly described here. Where alternatives are given, choice must be governed by conditions such as the extent, type and situation of the fire. Ventilation should always be shut down in the vicinity of any fire unless specifically stated otherwise.

Structural and general fires

Two-gallon water extinguishers or spray nozzles should be used, and the surroundings of the fire should be cooled by spraying. Smouldering solids must be broken up and thoroughly drenched. Careful watch must be kept when the fire is apparently out, because reignition is likely with this type of fire.

Magazine and shell room fires

These should be sprayed, or sprayed and flooded if the fire is sufficiently dangerous. Surrounding compartments should be cooled with spray.

Inflammable liquid fires

Hand foam extinguishers or main foam appliances should be used. In engine rooms and certain other machinery spaces foam tubes are fitted to direct the foam to the bilges. Foam should not be directed at the surface of burning liquid as it will disturb the surface and scatter the burning fuel. It should be played on a vertical surface in the vicinity, whence it will run down and cover the surface of the burning fuel. Spray is effective on liquid fuel fires provided that all the surface of the burning liquid can be reached.

Gasoline and other highly inflammable liquids. Hand foam extinguishers or main foam appliances should be used. Spray is useful for cooling the surroundings, but should not be used on the fire itself. In a compartment fitted with spraying arrangements (e.g. dope room, inflammable store) a very small fire should be attacked at first with a 2-gallon foam extinguisher, but a large fire must be dealt with by spraying.

Machinery spaces

There are often two distinct phases in the development of fires in machinery spaces and in the method of tackling them:

1. Direct attack with 2-gallon foam extinguishers, spray nozzles, or F.B.5(X) branchpipes *before* the fire has gained large proportions.
2. Either steam smothering or the introduction of foam from main appliances *after* evacuation of the compartment has become necessary.

In the first phase the fans should be kept running to drive the smoke, and no attempt should be made to exclude air. If a spray nozzle is used, it should be used to sweep back the smoke. In the second phase the amount of air reaching the fire must be limited by every possible means. Foam and water must not be used together.

In ships with diesel engine propulsion, where no steam is available, the fixed CO_2 system should be used. Fixed foam sprinklers should be used for large fires in ships so fitted.

Aircraft fires on deck

Hand and main foam appliances, dry powder units and C.T.C. knapsack tank units may all be required.

Fires in hangars

Hand foam extinguishers or main foam appliances and, when necessary, the hangar sprays, should be used.

Fires in gasoline-engined small craft

In *engine rooms*, circumstances permitting, some attempt should be made to fight the fire locally with 2-gallon foam extinguishers before resorting to smothering by the fixed installation. In *tank compartments* the fixed system should be operated immediately a fire is detected. Even a preliminary inspection, involving the opening of hatches and the admission of more air, is liable to be highly dangerous. Ensure that everyone has left the compartment, close hatches and doors and make every effort to seal the compartment completely, including ventilators.

Electrical fires

An electrical fire in any installation using very high voltages (e.g. wireless, radar and sonar equipment) must be dealt with *only* by carbon dioxide. It is emphasized that even when the current is switched off these installations may retain a sufficient charge to give very severe shocks. When a fire involves electrical equipment at normal ship voltages, the current should be switched off if possible and the fire treated as an ordinary fire, i.e. by using the 2-gallon water extinguisher (which is filled with fresh water) or the spray/jet nozzle. If the current cannot be switched off, it is still safe at these voltages to use water in the form of a spray. *On no account should foam be used for electrical fires.*

FIRST AID FOR BURNS

First aid treatment of a burn should be carried out at once, either by the victim himself or by the nearest available person, the object being to relieve pain and prevent further injury. This is most easily and quickly done by protecting the burned surface from the air, and it should therefore be covered, in the same way as a wound, with a clean, dry dressing, which should be widely and firmly secured. One or more first aid field dressings, or any improvised pads of clean material folded to appropriate sizes, are suitable. Never attempt to pull off anything adhering to burns on the body, and never touch the surface of a burn or attempt to clean it.

A person who is burned will suffer from shock. First aid for shock must therefore be administered as follows:

1. Lay the patient flat in a safe place.
2. Get him warm.
3. Give him a hot, sweet drink.
4. If he is in pain give him morphia.

CHAPTER 3

Abandoning Ship, Survival and Rescue

This chapter describes the equipment and organization in the Royal Navy; the equipment and organization for abandoning ship and lifesaving in the Merchant Navy are described in Volume III (Chapter 5).

However remote the possibility of disaster from fire, collision, stranding or enemy action may be, seamen should always be prepared to abandon ship when necessary and take to the liferafts. Every seaman should also be prepared to rescue survivors from another ship. Preparation for such eventualities includes the provision of lifesaving equipment and training in its use, but the best equipment is of little value without good organization and high standards of discipline, leadership and morale.

A man's chance of survival after shipwreck is better today than at any time in the past. A lifejacket is designed to enable the wearer to jump safely into the sea from a considerable height and to keep the wearer's mouth and nose out of the water should he be unconscious or asleep. A survival suit keeps him warm, and an enclosed liferaft protects him from the elements and provides him with food and water until rescued.

The prospects of rescue have also been improved by radio beacons on which a searching aircraft can home from 100 miles, and by other aids to detection.

ABANDONING SHIP

Importance of training

Training prepares the individual psychologically for an emergency and reduces the mental and emotional shock caused by fear. This is due partly to familiarity with the procedure or drill, and partly to gaining a knowledge of the dangers to be faced and of the capabilities of the equipment provided. The passengers of a liner, for example, are less likely to panic when ordered to their boat stations in emergency if they have already attended several boat drills.

In the Royal Navy all men must have a thorough knowledge of the lifesaving equipment, and they should be drilled in its use. Facilities for gaining experience in the use of lifejackets and liferafts are available at all pre-entry training establishments. Courses are given at the Safety Equipment and Survival Training School; books are available (B.R. 1329, *Handbook for Survivors*, and B.R. 1977, *Life-saving Equipment Maintenance Manual*) and films can be shown (*Survival at Sea*, Parts I and II).

Organisation

In the Royal Navy the organisation which covers abandoning the ship (as well as other emergencies) and calls the men to special stations around the ship, is called 'Emergency stations'. The order 'Hands to emergency stations' is

broadcast over the ship's loudspeaker system, or is given by a series of blasts on the alarm buzzers. The word 'Emergency' is used to avoid any possible confusion with the final order 'Abandon ship', which is given only after all available liferafts have been slipped and when the ship is about to founder.

In a disciplined service such as the Royal Navy 'Emergency stations' is exercised frequently so that stations are manned quickly and order is maintained throughout. The responsibility for slipping the liferafts, after the order to do so has been given, rests with the senior officer (or rating) in charge of that particular group of men and liferafts.

Remarks on abandoning ship

When the order 'Hands to emergency stations' is piped all personnel should partially inflate their lifejackets. The lifejacket should be fully inflated by the time the order 'Abandon ship' is given. At the order 'Abandon ship' the result of discipline and training in the individual will be apparent. Board the raft as quickly as you can; if you can climb down a rope or hose and get into the raft dry-shod so much the better: but if you have to jump into the water this can be done quite safely from any height when wearing the Naval inflatable lifejacket. You should jump feet first, keeping the feet together, placing one arm over the front of the stole and pinching the nostrils with the other hand. This will ensure a safe drop into the water, prevent any undue movement of the lifejacket and stop water being forced up the nose.

Anyone left on the ship after the rafts have got away should abandon ship and swim as far as possible to avoid being sucked down or entangled in the rigging as the ship founders, and to avoid being struck by wreckage which might subsequently rise to the surface with great force. The only efficient way to swim when wearing an inflatable lifejacket is on the back.

When abandoning ship the following points should be remembered:

1. If the ship is drifting it is better to leave her over the weather side, otherwise it may be difficult to swim clear; but jump well clear of the side and swim quickly away to avoid being washed back on board by a sea.
2. If the ship is listed leave her over the bows or stern, if possible. If you jump from the high side you may strike the bilge keel or propellers, or injure your hands and feet on barnacles on the exposed part of her bottom, and if you leave by the low side you may be struck by the superstructure, masts or funnels if the ship capsizes before you can swim clear.
3. Men have safely negotiated a patch of more than 200 yards of burning oil in the following manner. Remove your lifejacket and any heavy clothing; take a deep breath and jump in feet first; swim under water for as long as possible, then spring above the flames and take another breath while pushing away the flames with a breast stroke; then sink and swim under water again.
4. If anti-submarine mortars are being fired or any other explosions are taking place in the water, swim on the back and lift the trunk as high as possible out of the water to avoid the pressure wave of the explosion.
5. When clear of the ship swimmers should cling to any floating wreckage available and form themselves in compact groups to provide mutual support and encouragement. When possible, swimmers in a group should rope

themselves together by means of the toggle and line on the lifejackets, preferably in a circle facing outwards, and they should avoid undue exertion. A group of swimmers stands a better chance of being rescued than do individuals.

LIFESAVING EQUIPMENT

Lifejackets

The standard lifejacket used in the Royal Navy is the *General Service Naval inflatable lifejacket* (Patt. 5580) (fig. 3–1). The number supplied to ships is based on the full war complement plus 10 per cent plus a number sufficient to equip all boats. They are issued to ratings when they join a ship in peace-time; they are a personal issue in war-time.

The inflatable stole is packed in a pouch worn in the small of the back so that it does not hinder the wearer. When danger threatens, the pouch is pulled to the front and unbuttoned, and the stole of the jacket is slipped over the head. It is inflated by removing the inflation tube from the retaining loop, unscrewing the rubber or plastic mouthpiece and blowing into the tube while the mouth is pressed against a light spring so as to unseat the valve and allow the air to pass. A few puffs are sufficient to provide buoyancy in the water and the jacket will still permit a reasonable amount of movement of the head and arms. But to ensure self-righting if a man is knocked unconscious into the water, the stole must have been blown up tight. The valve is screwed shut after inflation and stowed in the loop. When fully inflated the lifejacket will cause the wearer to float on his back at an angle of about 45 degrees, so any swimming must be done on the back. In this attitude the head is supported clear of the water, so that an unconscious or sleeping man is still able to breathe.

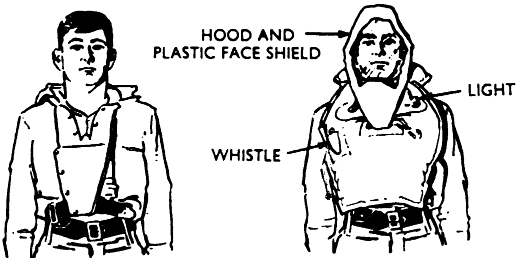
The lifejacket is fitted with a hoisting harness and a line and toggle so that the survivor may secure himself to other survivors or to any suitable floating object. There is a whistle and a lamp; the latter's battery must not be wasted, because it may be needed to reach the abandon ship station and to guide rescuers in the water.

The security of the lifejacket and the operation of the mouth valve should be tested daily. Inspection of the rubber parts, battery, lamp and whistle is also required.

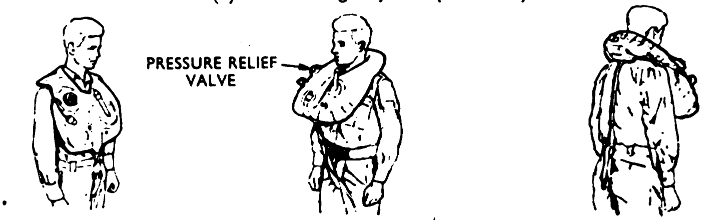
Restowing the lifejacket

1. Deflate the jacket completely by unscrewing and depressing the spring-loaded inflation valve and pressing and rolling the stole.
2. Lay out flat, wash off any salt with fresh water, dry, dust with French chalk and remove all creases.
3. See that the harness is attached by the three press-studs.
4. Replace the mouthpiece in its retaining loop and stow the toggle and line in the bottom of the pouch.
5. Fold the sides inwards to make the width equal to the length of the pouch.
6. Stow the bottom of the stole; then, starting from the neck, roll the jacket tightly down into the pouch.

(i) General service naval inflatable lifejacket (A P. 5580)

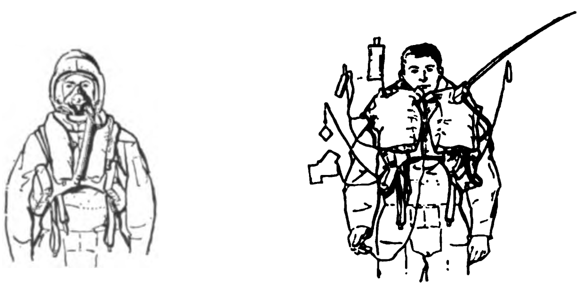


(ii) Self-inflating lifejacket (A.P. 5657)



(iii) Submariner's lifejacket (A.P. 5581)

(iv) Assault troop's lifejacket (A.P. 5582)



(v) Aircrew lifejacket

FIG. 3–1. Lifejackets

The *Inherently-buoyant lifejacket* (Patt. 5656) is intended for use when an inflatable lifejacket may be damaged in the course of a man's work.

The *Self-inflating lifejacket* (Patt. 5657) is designed to give maximum freedom of movement. It is fitted with a gas cylinder which inflates the stole automatically and fully within a few seconds of immersion. It is intended for men in exposed positions who may find themselves in the water without warning—for example, boats' crews, men in dangerous positions during replenishment operations, and men sent over the side at sea. The gas inflation system can be operated manually, and there is a mouth inflation tube for topping up when in the water. The lifejacket should never be partially inflated by mouth before the gas inflation system is operated because the additional pressure may burst the stole.

As wearers of the lifejacket are likely to become 'man-overboard' cases and some time may elapse before they are picked up, the lifejacket is fitted with a face shield, a heliograph mirror, a whistle and a light that is brighter than that fitted to other lifejackets.

The *Submariner's lifejacket* (Patt. 5581) differs from the Naval inflatable lifejacket in the following respects:

it has a relief valve which automatically takes account of the pressure differences as the survivor ascends to the surface;
the mouth inflation valve is of different design, and has to be depressed by a special key in order to deflate the stole;
the battery for the torch unit is sea-activated;
the belt fastening is buckle-adjusted;
there is no lifting harness.

Other lifejackets. The *Assault Troops' lifejacket* (Patt. 5582) and the *Canoeist's and Underwater Swimmer's lifejacket* (Patt. 2221) are fitted for gas and oral inflation. The stole of the Patt. 2221 lifejacket is reversible.

Inflatable liferafts

These have now completely replaced lifeboats in men-of-war and partly replaced them in merchant ships (see Vol. III). They are supplied on a scale of raft seats for the full war complement plus 10 per cent rafts spare. There are two sizes, the 8-man liferaft for very small ships and craft and the 20-man liferaft. They are packed tightly in weather-proofed canvas valises, and in some ships in glass-reinforced plastic containers.

Associated with a liferaft is a survival pack containing food, water, first-aid kit, repair outfit, etc. The pack for the 8-man liferaft is stowed inside the raft, while the pack for the 20-man liferaft is separate and stowed above the liferaft valise (fig. 3–2). Both pack and valise are held in place by canvas webbing and protected by a cover which are either slipped by hand or released hydrostatically if the ship founders before this can be done. When the pack and valise have been launched overboard the valise remains secured to a strong-point near the stowage by an operating cord. One or more sharp pulls on this cord operates a gas release mechanism, and the raft then inflates and bursts out of the valise. If there has been no time to slip the webbing and cover by hand, the pack and valise will rise from the foundering ship when the cover is hydrostatically released: the operating cord being drawn out to its full length,

the tension in the cord operates the gas release mechanism and the raft inflates; its buoyancy then overcomes the strength of the operating cord, which parts, and the raft floats to the surface.

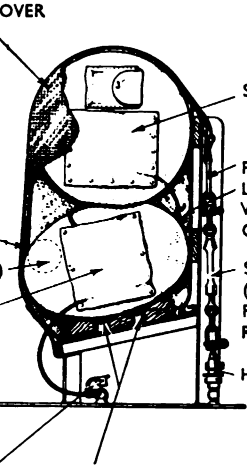


FIG. 3–2. Liferaft stowage

20-man liferaft (fig. 3–4)

When packed in its valise the 20-man liferaft measures approximately 5 ft by 2 ft by 1½ ft and weighs about 230 lb. Webbing straps are fitted to form lifting handles. Along the top of the valise are eyelets for the lacing. For transport, this lacing is of 12-oz hemp or more, but it is replaced by No. 1 flax-braided cord when the valise is in its proper stowage. This final lacing will break when the raft inflates. At one end or side of the valise a protective flap covers the position where the operating cord is faked between rows of beckets. This operating cord is part of the raft's painter after the raft is launched. A lazy line is bent to the towing bridle of the raft and to the operating cord. On inflation, under normal conditions of launching, the operating cable pulls clear from the gas bottles and raft; but the operating cord remains secured to the lazy line, and thence to the towing bridle. The raft therefore remains secured to the ship, the operating cord and lazy line together forming the painter (fig. 3–3).

The seaman must have a good knowledge of the construction of the liferaft and how it is operated. B.R. 1977(1), *Handbook of the 20-man Liferaft and Survival Pack*, contains more detailed instructions. Everything learnt at this stage will increase the chance of survival, as will be seen later.

The raft consists of an oval main buoyancy tube (16 ft by 10 ft) to which are attached a thwart, a floor and two arches, all of which are inflatable. The floor consists of two layers of material. A tent, which consists of two layers separated by an air space, is supported by the arches and fixed to the buoyancy

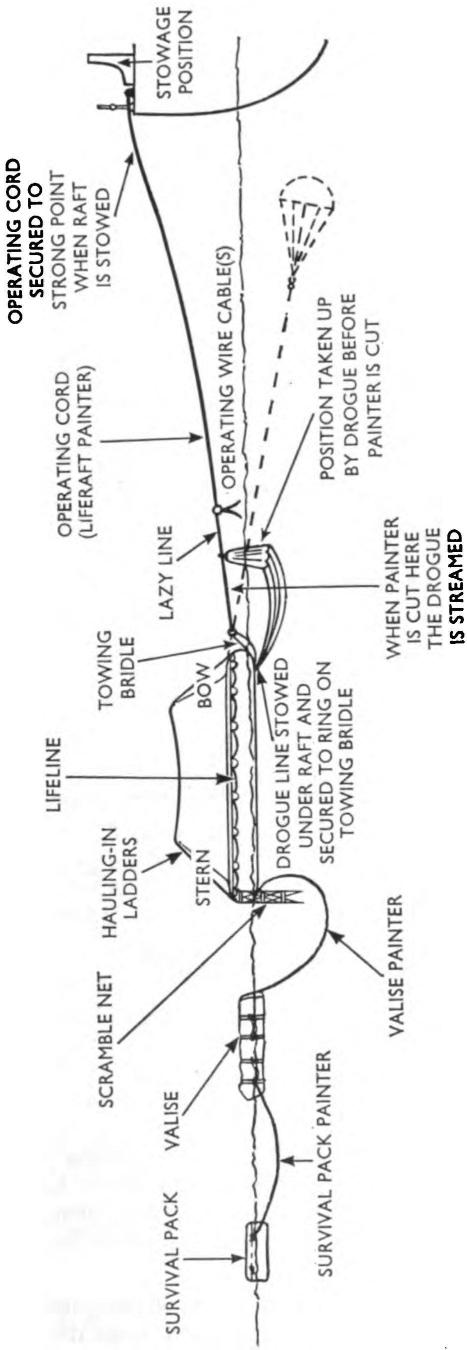


FIG. 3-3. Liferaft launched and inflated

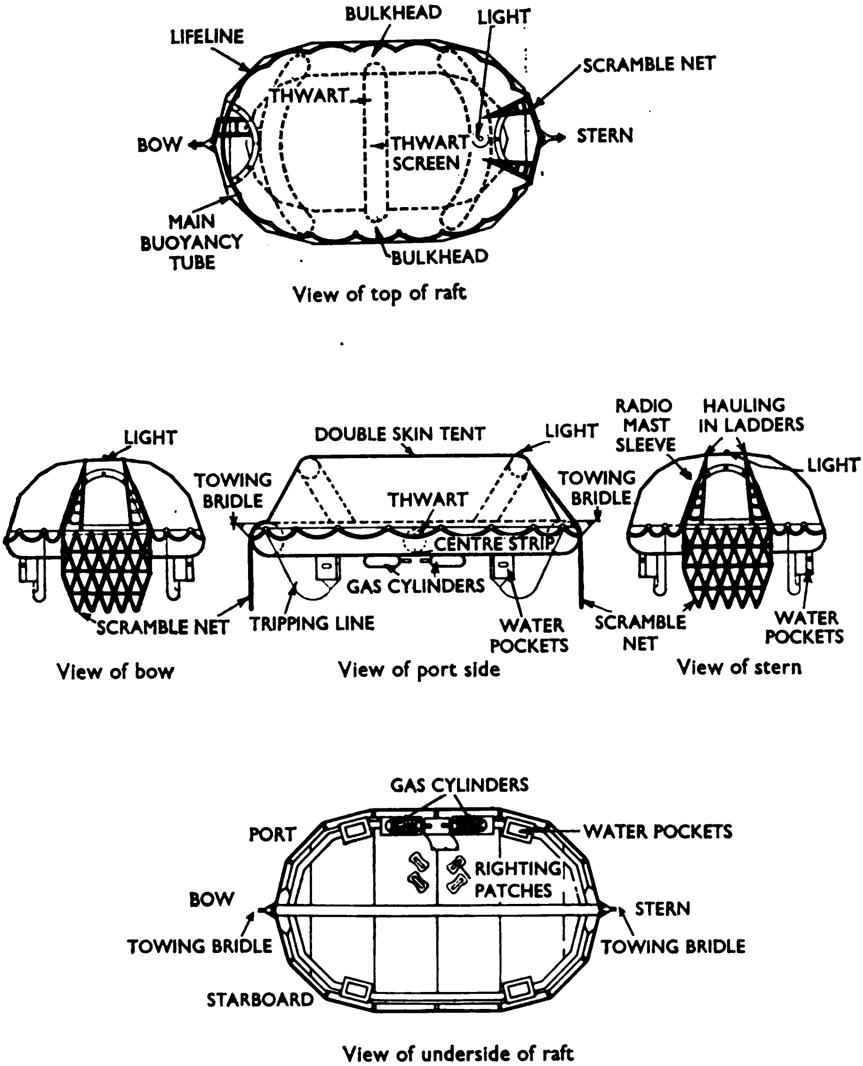


FIG. 3–4. 20-man liferaft

tube. Two inflatable cushions are fitted round the periphery of the main buoyancy tube, one on each side of the thwart. Occupants of the raft are therefore protected by a layer of air or gas which insulates them from extremes of temperature outside the raft. The whole raft is made of rubber-proofed cotton fabric.

When launched, the main buoyancy tube, arches and thwart are automatically inflated from the gas cylinders attached under the raft. The floor and seat tubes are inflated by hand bellows. The main buoyancy tube is divided athwartships by two vertical bulkheads. Each half has its own inflation valve,

safety and topping-up valve and deflation plug. Defects in one half will not therefore affect the other.

The arches are sealed off from the main buoyancy tube except for two non-return valves, one connecting with each half of the buoyancy tube. A vertical bulkhead runs the length of the thwart and acts as a seal or reserve wall should the thwart be punctured on either side.

At each end is a towing bridle, the centre webbing leg of which is common to both, running the full length underneath the raft. Attached to the forward towing bridle is the lazy line and a drogue with line which automatically ejects itself when the raft is inflated. A lifeline is secured in loops round the outside of the main buoyancy tube and a scramble net is slung from sleeve entrances at the bow and stern. These entrances can be adjusted for size of opening by tapes and drawstrings; they can also be rigged as awnings in the tropics by fitting the awning struts provided in the survival pack.

On the underside of the raft there are four handling loops for righting the raft if capsized, and four water pockets to check wind drift and prevent capsizing. Each pocket is fitted with a trip line for spilling the water when it is desired to increase drift, to manoeuvre or be towed.

The inflation equipment consists of one or two cylinders charged with a total of 14 lb of CO_2/nitrogen gas. Attached to each cylinder is an operating head which is the mechanism for releasing the gas when the wire operating cables are pulled by the operating cord.

Equipment fitted in the raft. A complete list of the equipment fitted in the 20-man and 8-man liferafts will be found in B.R. 1329, *Handbook for Survivors*. Here it is intended to describe some of the equipment and its stowage.

A rescue quoit on 100 yards of buoyant line is stowed in a pocket near both entrances.

Leak stoppers of various sizes are stowed in a pocket on the port side forward.

Hand bellows are stowed on top of the thwart on the starboard side. Both safety and topping-up valves are fitted on the same side so that the bellows can be used without being removed from their stowage.

A marker light, fitted on top of the after arch, is fed from a sea-activated cell fitted in a pocket under the raft. To conserve the life of the cell the leads should be disconnected and the cell left in the water.

A stowage for B.R. 1329, *Handbook for Survivors*, and a heliograph will be found in a pocket near the stern or main entrance.

A flax webbing rescue strop for hauling in distressed survivors is stowed near the stern or main entrance.

Solar stills are stowed in pockets on the port side of the raft. Instructions on how to use them are printed on the outside and in a leaflet supplied with them.

Rain water saddle bags are stowed inside the raft, on the starboard side.

8-man liferaft (fig. 3–5)

This consists of a circular buoyancy tube 9 ft in diameter, to which is attached an inflatable arch supporting a tent in a similar manner to the 20-man raft.

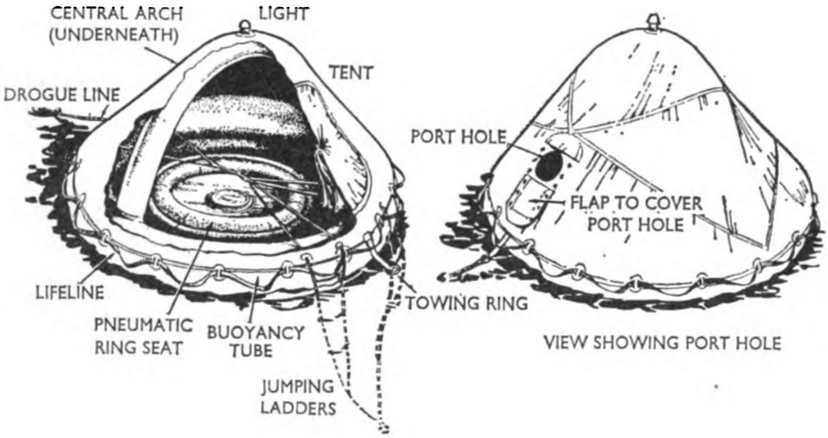


FIG. 3–5. 8-man liferaft

The buoyancy tube is divided in half by vertical baffles and supports a double-skinned floor. The floor and circular seat assembly round the circumference can be inflated by hand. The entrance on one side of the arch is the same in principle as that in the larger raft, and a small opening is provided on the other side of the arch for ventilation and observation purposes.

Boarding the raft from the water

Hold the lifeline that is near the scramble net with one hand, put the left foot on the bottom rung of the hauling-in ladder, transfer the hands to the ladder and scramble aboard. Another method is to grab the lifeline, place both feet on the scramble net, and grab the hauling-in ladder as high as possible; then put both feet as high as possible on the scramble net, straighten the legs, pull with the arms, and lunge aboard face downwards. Boarding is made easier if the lifejacket is not fully inflated.

If the raft is capsized (fig. 3–6) it can be righted by one man manoeuvring himself to a position close to the gas cylinders and grasping the lower set of

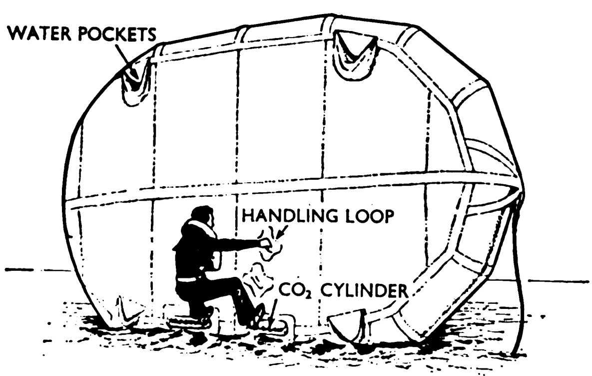


FIG. 3–6. Righting a capsized liferaft

handling loops. He should then climb on to the cylinders, transferring his grasp to the upper handling loops. A pull on these loops, together with downward pressure of the feet on the cylinders, at the same time throwing the weight backwards, should right the raft, provided that the topsides of the raft are up-wind. Because of the large beam of the raft, the man righting it must be prepared to submerge and to swim out from under it. It is better, however, to push the raft away with the feet and pass across the underside of the raft.

Cutting loose. As soon as the raft has a full complement (if circumstances merit keeping the raft alongside), cut the painter with the safety knife sited on the buoyancy tube of the raft, just inside the bow entrance. The safety knife must be used; any other knife used hastily in an emergency might result in the buoyancy tube being cut. If you can manoeuvre the raft clear of the ship do so by using the drogue. Then keep the rafts close together and post a lookout for survivors in the water.

Recovery of a survivor from the water

Throw a quoit and line, or if the survivor is too distant send out a strong swimmer from the raft with the quoit and line.

If the survivor is injured haul him alongside with his back to the raft. The rescuer in the raft should stand with his feet fairly close together and his legs pressed against the buoyancy tube. Reaching outboard, he should pass his hands under the survivor's arms and clasp them on his chest. If this is not possible grasp the survivor's clothing on each shoulder. Push downwards before starting the upward pull, when the rescuer's arms and body should be straightened and the weight thrown backwards. If there are two rescuers, each can grasp with one hand the becket of the survivor's lifejacket.

Another method is to use the rescue strop. Place the strop across the shoulder blades and then under the arms. Push the survivor downwards, then pull on the strop as the survivor surges upwards. The survivor can be facing the raft or with his back to it.

Survival pack

The survival pack of the 20-man liferaft is stowed on top of the raft and its painter is secured to the lifting handle of the valise on the side opposite the cylinders. The painter is 60 ft long and allows for separate launching of the pack and raft. The pack contains rations for the full complement for five days and certain equipment listed in the handbook (B.R. 1977(1)). The survival pack for the 8-man liferaft is stowed inside the raft.

Distress signals are contained in pockets on the outside of the valises on the 8-man and 20-man survival packs. They are exchanged every year.

Liferaft maintenance on board

Every inflatable liferaft is maintained in a state of readiness for launching and inflation, and inspections are carried out regularly to ensure that every liferaft is in a serviceable condition. A daily inspection includes inspection of the cover for rents, burns, damage by rats, dampness and signs of acid, oil or grease;

checking of the screw and slip or the hydrostatic release gear, if fitted, also the attachment of the operating cord to the strong-point. A six-monthly inspection, for which the raft need not be removed from the valise or disturbed more than necessary, includes the following:

1. Inspect the cover and remove it to expose the valise. Check that the operating cord is secured to the strong-point.
2. Inspect the valise for any signs of damage, wear, oil, acid (testing with litmus paper), grease, etc. Check the serviceability of the webbing lifting handles.
3. Examine the lacings and operating cord for signs of fraying or damage, and examine the grommets and eyelets for serviceability and attachment.
4. Examine the press-studs on the operating cord protection flap for corrosion, attachment and operation.
5. Check serviceability of the slip and screw and of the hydrostatic release gear, if fitted.
6. Replace the cover and, if it is of canvas, give it a protective coat of paint if necessary, but do *not* paint the cover if it is made of P.V.C.-coated Nylon.

A number of spare, fully-charged gas cylinders, operating heads, operating cords, valises and valise lacings are carried on board. In addition, a number of items, including replacement parts, patches, solution and repair tools, are carried for keeping the raft used for wet drill in a serviceable condition.

Generally, the liferafts are received on board packed in a valise complete with all equipment, including gas cylinders and operating heads and with the operating cord connected to the operating cables (see 'Raft supply and checking', below). The valise is laced with strong cord and a light breaking cord is attached. This breaking cord should be laced through the eyelets and the strong cord removed. The raft is then operational.

In some cases the cylinders and operating heads are supplied separately, and the instructions given in B.R. 1977(1) must be followed to make the raft operational.

Radio equipment

One of the rafts in a survival group must carry a buoyant portable radio set with a hand-operated generator. At emergency stations it is provided and secured to the raft valise before the raft is cast overboard. It should be tested at six-monthly intervals. Installation and operating instructions are included with the equipment.

Raft supply and checking

The scale of liferafts supplied to ships in commission is given on page 45. In ships under construction, modernisation or conversion the rafts will be supplied and fitted as 'first fitting' stores.

It is most important to ensure that the cylinders and operating heads have been connected up in their correct orientation before the rafts are stowed. This is normally done by dockyard personnel only at the time of issue. All issue vouchers, in addition to showing the serial numbers of the rafts, will bear one of the following endorsements: 'Complete with cylinders and operating

heads connected', or 'Incomplete—cylinders and operating heads to be connected before issue'.

Outfits of liferafts should not be held on board any ship for longer than three years, after which arrangements should be made for exchange.

Practice raft

One raft should be set aside for practice purposes. This is necessary because a raft which has been inflated and launched in sea water needs a lot of attention before it is restowed. The practice raft should be stowed in a position from which it can easily be slipped and launched.

When recovering the practice raft it should be brought on board fully inflated. It should then be washed with fresh water, making sure that all cordage is well soaked to remove the brine. Allow the raft to dry naturally and inspect and dry all metal parts. Fit the dust-caps to the safety topping-up valves and see that the sleeve entrances are furled and tied. Dust liberally with French chalk and then remove the dust-caps.

Before being folded and packed into its valise it is essential to expel all the air and gas from the raft. This cannot be done completely by merely removing the deflation plugs of each compartment, but the gas and/or air must be sucked out by an electric deflation pump, which operates like a vacuum cleaner. The end of the pump hose has a screw adaptor for the deflation plug connections.

Follow the special folding procedure given in B.R. 1977(1), the liferaft handbook, and restow in the operational condition.

Clothing

Clothing is of considerable importance in prolonging the time of survival of a man in the water. All clothes, including socks and footwear, should be kept on. In cold waters survival suits (fig. 3–7) and Neoprene gloves are supplied on a personal basis; they are carried in a pouch next to the lifejacket pouch. The

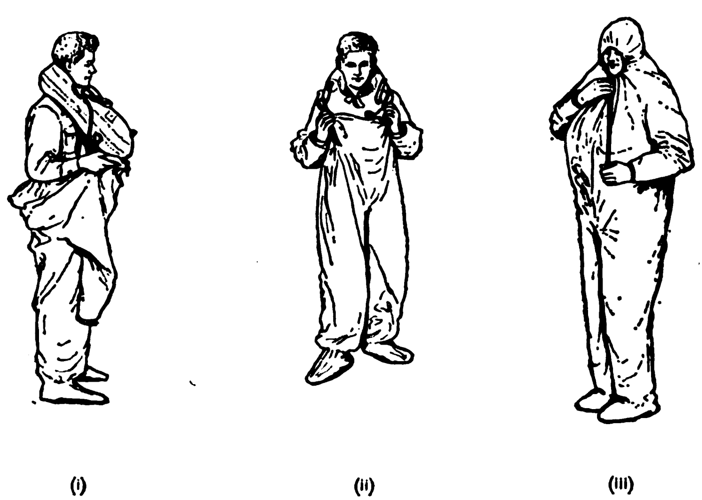


FIG. 3–7. Survival suit

suit is a one-piece garment, entered from the neck, with wrist seals and a drawstring at the neck. The suit is waterproof and greatly increases the chances of survival if a liferaft cannot be reached, but it annuls the self-righting property of the lifejacket.

Scramble nets

These nets should be securely stowed along the ship's gunwales at places where freeboard is lowest, but they must be kept well clear of the propellers. When unstopped they should hang about one foot clear of the ship's side, with their lower edges at least 2 ft under water when the ship is at light draught; they should be spread on spars or battens fitted at intervals of 3 ft, and the lower edges should be weighted with metal tubes or bars.

The nets and their spars should never be painted. They should be protected from funnel gases, oil, grease and dirt by painted canvas covers, and should be stowed on chocks clear of the waterways.

Lifelines and jumping ladders

Both of these should be long enough to reach to the waterline when the ship is at light load draught and listed 15 degrees to the opposite side. Except in ships with low freeboard, the lifelines should be knotted or fitted with standing Turk's heads at intervals of a few feet to provide handholds and footholds; and, when practicable, they should be rigged over chocks so that they hang clear of the ship's side. Ladders should be stowed rolled up and secured by strops and toggles to the bulwarks or guardrails, clear of the deck. Neither lifelines nor ladders should be painted, and they should be protected from grease, oil and funnel gases.

Lifeboats

In the Royal Navy boats are not included in the ship's lifesaving complement. However, in the Merchant Navy lifeboats and lifesaving equipment carried aboard ships must conform to the strict standards set forth by the International Conference for the Safety of Life at Sea and enforced in this country by the Ministry of Transport. It is obvious that, whereas a sailor can jump from the deck of a sinking ship and swim to a liferaft, it is not always so in the case of untrained and often elderly persons such as those carried aboard passenger liners. Therefore lifeboats comprise the larger part of lifesaving equipment in the Merchant Navy passenger-carrying fleet. Details of such lifeboats, of the various methods of turning out and lowering them, of the stores carried and of other lifesaving equipment will be found in Volume III.

SURVIVAL

The previous pages have dealt in general with getting off the ship before she finally sinks, and reaching some floating object, be it liferaft or timber. The following paragraphs show how men can stay alive until rescued. Each liferaft contains a copy of B.R. 1329, *Handbook for Survivors*, which must be reread by all personnel as soon as possible after boarding the raft.

SURVIVAL AT SEA

You should never attempt to sail away from the area where your ship has sunk. Although the prevailing conditions of wind and stream will make your liferaft drift, all the rafts will drift roughly in the same direction and therefore the search area will not be increased. The Navy Department will know where your ship was sunk and will rapidly organize a search. You may confidently expect to be rescued within a few days. It is highly unlikely that you will drown in the Naval inflatable lifejacket if it is fully inflated. The exposure suit will keep you warm in the water, and you will not die from chill once you are in the liferaft. Sufficient water is provided to prevent your being dehydrated by the time rescue arrives, and rescue will certainly come before starvation sets in.

The qualities which are essential to the survival of the crews of boats or rafts when adrift in the open sea are a determination to survive, discipline, confidence, cheerfulness and willingness. Whoever is in charge of a raft has the most exacting task, because, in addition to looking after the safety of his craft, he must inspire the crew with confidence both in himself and themselves, maintain strict but sympathetic discipline at all times, and always appear cheerful and optimistic. He should arrange for each of the crew to be given a specific duty, and should work out a daily routine and see that it is strictly carried out. He must also take charge of the rations and supervise their issue, and make sure that the sick and wounded are looked after.

Immediate action on boarding raft

Check the raft for leaks. Top up buoyancy tube, if necessary. Inflate floor and seat units. Then secure survival pack and radio set, if one is available.

Since trials have shown that all, or nearly all, personnel in a liferaft will suffer from sea-sickness, issue sea-sickness tablets to every man, whether he wants them or not. There is a ready-use supply in the distress signal pocket.

Adjust the inner and outer sleeves in the weather covers according to the climate and state of the sea.

Post a lookout and search for survivors.

Treat injuries, even minor ones, immediately. Instructions are given in the first aid kit and in the *Handbook for Survivors*.

Gather any wreckage which you think may be useful. Containers of any type are valuable, as will be seen later in this chapter. Extra clothing is of vital and immediate importance in cold weather.

Secure to other rafts if possible. Then dry out the raft, using bailers and sponges, spare wet clothing or any suitable containers. Wring out all wet clothes.

If you do not pass urine within two to three hours of boarding the raft great difficulty will be experienced in doing so later. You must force yourself to do so.

General subsequent action

When rafts are congregated the senior officer or rating takes command of the flotilla, appoints a leader in each raft and musters all the survivors. Stores, equipment and spare clothing in each raft are mustered and shared out equally amongst the flotilla (in cold weather, after the rafts have been warmed up).

A roster of work (ration-keeper, lookout, repair party, bailers, etc.) must be started as soon as possible. It is most important to keep the mind occupied and physical exertion to a minimum.

Ensure that the distress and other signalling aids are immediately to hand, particularly at night and in low visibility. The distress signals must be transferred from the survival pack to the raft; the heliograph is in the handbook pocket of the raft.

No sharp-edged pieces of hard metal such as unsheathed knives, worn boot protectors, jagged tins and the tongues of buckles of overalls should be left in the raft to cause leaks.

Action in cold climates

Close the outer and inner sleeves at each end of the raft and inflate the floor and seat, making sure that there are no leaks of CO_2 gas into the raft. To close the sleeves untie the furling tapes and pull the drawstrings taut. Tie the drawstrings or, if fitted with a sliding cleat, push the cleat as far along the drawstring as it will go and secure with a half-hitch round the cleat. Tie off the outer sleeves by bending back bunched fabric and lashing it with the ends of the drawstrings.

If there are men chilled from immersion and shivering uncontrollably, warm them by getting everybody to huddle closely together.

When men are warm the sleeves must be opened slightly for ventilation; bring the rafts up to full complement and keep the empty rafts; then exchange stores, equipment and spare clothing between rafts.

It is essential to keep as warm and dry as possible. Cover yourself with all the spare clothing you have been able to salvage, keep the floor of the raft as dry as possible and huddle close together. Keep moving your toes, fingers, hands and feet, clench your fists and stretch your limbs to assist circulation.

Avoid exposure. Face, ears and hands are quickly affected by frostbite. Lookouts must be well wrapped up.

Action in hot climates

To preserve the body water avoid all unnecessary exercise and exposure to the sun. Spread the awnings, open the inner sleeves fully and, in daytime, deflate the floor and seat.

Keep the outside of the tent wet with sea water to reduce the inside temperature. No man should spend more than 10 minutes on sousing duty and he must use the ointment from the first aid pack to avoid getting sunburnt.

Even if you are not feeling hot, keep all your clothing wet by day; but the

clothing and the floor of the raft must be dry by sunset, because tropical nights can be very cold.

PROVISIONS

Water

Man can survive for upwards of 30 days without food provided he has sufficient drinking water. Without water his chances of survival are greatly reduced. As much water as can be stowed in the survival pack is therefore supplied; it is on the scale of five 17-oz cans per man. No water is drunk on the first day adrift; the ration therefore lasts six days. In the Second World War it was exceptional for survivors to be adrift for more than three days; with the improved aids to detection now available the time adrift should be much reduced. The water ration is therefore well on the side of safety, but it should not be wasted or used indiscriminately, because rescue may be delayed. There is no need to issue any water for the first 24 hours, because it is assumed that everyone has had his normal intake of food and water during the previous 24 hours and that further intake and the subsequent bowel movements would be a waste of the limited rations and of body water. Try to drink as much water as you can before abandoning ship. If a man has been wounded and has obviously bled a lot, or has been badly burned, water may have to be given to him at once.

Each can of water contains one man's ration for one day. The plastic beaker is marked for one-third of the total daily ration. Drink one-third at sunrise, at midday and at sunset. You must not ration yourself more strictly because you will weaken yourself and lessen your chance of survival. Only when you are down to the last day's ration is it permissible to impose more strict rationing. Do not attempt to supplement your water ration by drinking your urine. It is harmful because it contains many poisonous substances.

Sea water. Much has been written for and against drinking sea water. Whatever your personal views may be ***you must not drink it.*** Forcibly restrain anyone who tries to drink it. Don't use sea water to soften cracked lips, but use the deoiling paste.

Rain water. The liferaft is constructed so that the canopy can be used as a rain water catchment. There is a drain tube in the centre through which the water can be led to the saddle bag (fig. 3–8). Lash the drain tube to the thwart to make a depression in the canopy.

In the tropics rainstorms can be heavy and frequent. Fill the saddle bag and also every other container that you can find, such as boots, shoes and inflatable lifejackets. (The end of the tube fits snugly over the mouthpiece of the lifejacket, which can be filled with 27 lb of water when the valve is pressed down.) Only after all the possible containers have been filled should each man drink his fill from the continuing supply. Apart from this instance, the ration must remain at one pint per man per day, but remember to use the collected water first. It is a wise precaution to allow the first rain water to be wasted as it will surely be contaminated by either French chalk or salt from the top of the canopy.

The lookout should not just be directed to look for ships but also to rouse all the crew when rain occurs.

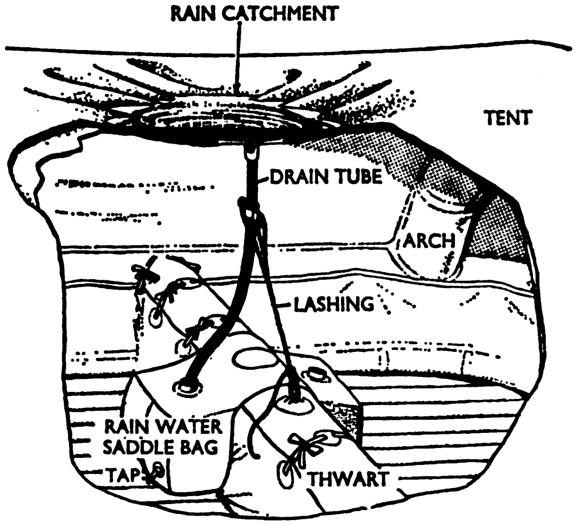


FIG. 3-8. Collecting rain water

Solar stills are stowed in the liferafts and, when blown up and streamed astern, may each provide as much as 1½ pints or more of water a day. What has been said about rain water applies to sun-distilled water—drink it before drinking the water provided in the sealed cans.

Condensation. Water will condense on the inner lining of the tent and should, if possible, be collected. Do not contaminate it with sea water on the raft floor, and remember that at first it will contain French chalk which is used as a drying powder when the raft is packed.

Snow and ice. Water can be obtained by melting snow from the outside of the raft; also from sheltered pools and melted ice of blue icebergs (old icebergs). (Approach carefully, because these old bergs may topple without warning.) New icebergs are a milky-grey colour and their ice is salty and must not be used for drinking water. Do not suck ice—melt it, and then, if it is not salty, drink it.

Food

The food ration in the survival pack consists of glucose sweets, each daily ration of 4 oz being split into three packets. Glucose sweets are the best food for survivors at sea; they give sufficient energy and body heat to keep the survivors fit and help to prevent dehydration of the body. It is left to your leader's discretion as to when you actually eat them, but eat your daily ration every day, preferably at the normal mealtimes.

The food ration can be supplemented with sea food, but fish or bird flesh must not be eaten unless you have been able to drink at least 1½ pints of collected drinking water in addition to the water ration the same day. The reason for this is given in the *Handbook for Survivors;* but the most important thing to remember is that drinking water is of more value to you than food.

Danger from fish

From a floating raft, particularly in tropical waters, many varieties of fish will be seen, ranging from flying-fish, crab and octopus-like creatures to barracuda, turtle, porpoise, giant ray, shark and whale.

Sharks, porpoises, giant rays and whales will not attack your raft if they are left alone. But never attempt to catch a shark or trail anything that may attract one. Never dangle arms and legs in the water, because sharks and other fish may be lurking out of sight.

First aid and care of the sick and injured

It is true to say that when you are sick or injured your chance of survival is greatly increased when equipment, and directions on how to use the equipment, are at hand. It is most unlikely that, after your ship has been abandoned and the liferafts manned, you will not find some of your shipmates requiring medical attention of one kind or another; and not only will you be assisting a sick or injured man to prolong his chance of survival, but he will be a member of your own ship's company and in all probability your friend. More detailed instructions on this subject are to be found in B.R. 1329, *Handbook for Survivors*. Here it is only intended to outline broadly this important subject.

Requirements. The first-aid pack, which contains dressings, bandages, pain-killing drugs and other medical stores, as well as instructions in their use, is in the survival pack.

An injured man needs *warmth*, *rest*, *relief from pain* and *control of bleeding*. Your circumstances and own common sense will tell you how best to keep him warm. Rest and relief from pain are obtained by the use of morphia if the pain is severe. Bleeding can be controlled by pressure of a pad of cotton wool or clothing firmly secured by a bandage. Tourniquets should not be used; any man injured so badly as to require one is not likely to be able to reach a raft by swimming.

Wounds should be treated by covering them with a dressing supplied from the first-aid pack. The first dressing need not be disturbed for three or four days. If rescue has not arrived by then, the dressing should be removed, the wound washed in sea water and redressed. If proper dressings are not available any clean piece of cloth may be used. As far as possible, keep the injured part at rest. There is always a danger of sepsis occurring in a wound; it is recognized by redness and swelling around the edges of the wound and a clear or yellow discharge which may have a foul smell. Sepsis is prevented by giving antibiotic tablets from the beginning, whether the wound shows signs of sepsis or not.

Burns. For first-aid purposes burns should be treated in the same way as serious wounds. If the burns are widespread there is severe shock and the burns easily become septic. Do not break blisters. Only just enough morphia to relieve the pain should be given. The burned areas should be covered with the gauze and cotton wool dressing (two thicknesses, if possible) and firmly secured with a bandage which overlaps the dressing. This overlap is important, because large quantities of fluid seep away from severe burns and add to the shock. Antibiotic tablets should be given from the beginning to men suffering from severe burns.

Broken bones. All that can be done in a liferaft is to keep the injured man

comfortable and free from pain by immobilizing the injured limb and so preventing the damage from getting worse. Put the limb in as natural a position as possible if so doing does not cause pain. Never apply force and don't worry about setting it accurately. If there is no pain the position of the limb is all right. A faulty setting can be put right after rescue.

Having got the limb in a comfortable position, the next step is to keep it there. For an arm or shoulder fracture, put the arm in a sling and bandage it to the chest. If the leg is broken, a piece of salvaged wood secured by bandages down the outside of the injured limb will serve as an improvised splint. Remember to pad the leg with spare clothing or cotton wool if the splint or the bandages are in contact with the limb. If you have nothing to use as a splint secure the broken leg to the sound one, remembering to pad between limbs and bandages. Wedge the injured man between two others to prevent him from rolling about with the motion of the raft; or use the raft valise as a litter.

Compound fractures. If there is a wound on the site of the broken bone or the skin has obviously been pierced by the broken end of the bone, do not try to set the limb at all, as movement may make the condition worse. Treat as a wound only and cover with a clean dressing. Give antibiotic tablets from the beginning, whether the wound becomes septic or not.

Oil fuel is dangerous only if it is swallowed. When it gets into the eyes it causes a violent inflammation, which will clear up in a few days. It is uncomfortable on the skin and can be removed with swabs or wads of waste material and Kerocleanse deoiling cream, which is provided in the survival pack.

Salt water boils and sores are likely to occur when the skin is sodden with sea water. Sodden skin has not the resistance of dry skin and it is liable to injury in trivial ways when moving about the raft. If a boil or ulcer develops, do not squeeze it. Keep it covered with a dressing and wait for it to heal itself.

Sunburn. You are often in more danger of being sunburnt in a raft than you would normally be. Sunburn is painful, and you must therefore protect yourself by covering the whole of your skin with clothing or handkerchiefs. Use the sunburn ointment in the first-aid pack.

Frostbite will occur only if the wind is allowed to play on the exposed skin. The areas affected are usually the face, ears and hands. To avoid frostbite keep these areas covered whilst acting as lookout, keep a watch on each other's faces for the tell-tale white patches, and try to keep your hands in your pockets. It is most unlikely that you will be frostbitten while you are inside the raft. The first signs are the dirty-white, waxy, opaque appearance of the skin, which will feel numb.

To treat frostbite keep the affected area warm, either with the palm of your hand or by covering it with cotton wool or other material. Do not massage the affected area, and never apply snow.

Immersion foot is a swelling, numbness, discoloration and ulceration caused by the feet becoming chilled and wet, with an inadequate blood supply in consequence. It may occur very quickly in Arctic waters. Keep your feet as dry and as warm as possible; exercise them at frequent intervals, making full ankle and knee movements as far as the space in the raft allows, and keep the floor of the raft as dry as possible in cold waters. If your feet begin to swell, take off your boots and wrap your feet in spare dry clothing, and at the same time keep

your feet elevated. Do not massage them. If ulcers develop cover them with clean dressings and cotton wool.

Care of an unconscious man. Make him comfortable, loosen any neckwear, keep him warm and treat his injuries. Do not give him any fluid or morphia.

Morale

The above remarks embrace the most that you can expect to be able to do for an injured or sick man in a liferaft. Having done this, it is now just as important for the safety of the crew as a whole to do all you can to preserve their morale and to keep them in a healthy mental state. Watch for any signs of unusual behaviour or speech which may indicate the breaking-down of morale. Encourage everybody by talking confidently but casually about being rescued. Avoid doing or saying things which annoy others and deal firmly with anyone who breaks this rule.

FIRST AID FOR THE APPARENTLY DROWNED

It is in the interests of all seamen to know how to apply artificial respiration to an apparently drowned person. Two methods are taught in the Royal Navy: the 'expired air' (mouth-to-mouth) method and the Holger Nielsen method. Each method is explained below and illustrated in figs. 3–9 and 3–10 respectively.

The expired air (mouth-to-mouth) method

This method gives a more reliable inflation of the lungs than the Holger Nielsen method described later and is of particular importance in the Royal Navy because it can be administered in a confined space or even whilst still in the water.

Procedure. Where possible, the patient should be placed on his back and the mouth quickly cleared of any obvious debris, such as water, oil fuel or seaweed. Place a folded coat or other support under the shoulders. Tilt back the head as far as possible (into the 'sword swallowing' position), when the mouth will usually open (fig. 3–9(i)). It is most important to hold the head right back to ensure a clear airway.

The operator takes a deep breath and places his mouth, wide-open, over that of the patient. The patient's nostrils may be closed with the cheek or pinched between the thumb and forefinger of the convenient hand (fig. 3–9(ii)).

The operator now breathes strongly into the patient's lungs, thereby raising the chest. He then takes his mouth away and turns his head to one side to observe the chest fall (fig. 3–9(iii)). At the same time he may hear the air escaping from the lungs. (This falling of the chest is a sign that the inflation has been effective.) When the chest has ceased to fall the inflation is repeated and the cycle continued until natural breathing is restored or hope is abandoned.

If the chest fails to move, check clearness of the mouth and the position of the head. In a few cases it may be necessary, by pressing behind the angles of the jaw, to push the jaw forward.

When breathing into a child's lungs much less force is needed than when inflating an adult's. With babies, gentle puffs only should be used.

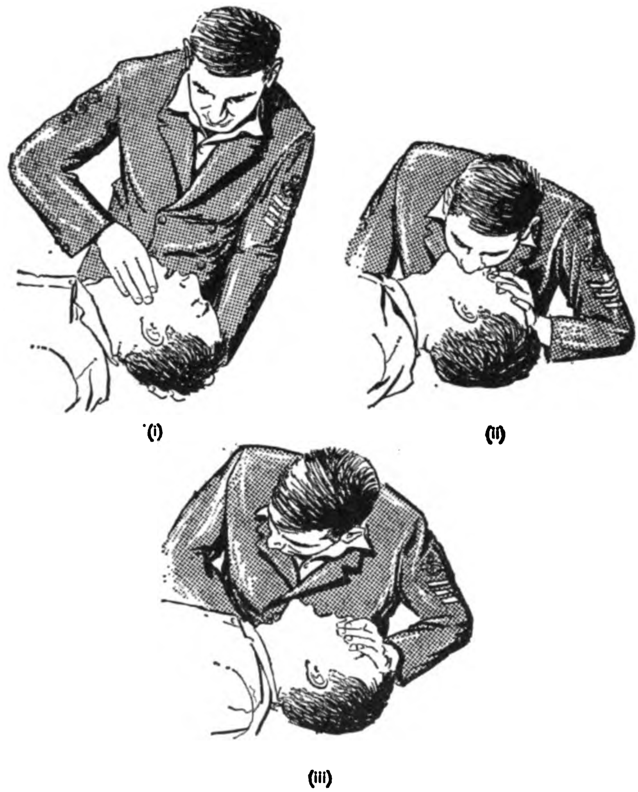


FIG. 3–9. Expired air method of resuscitation

If it is preferred to inflate the patient's lungs through the nose, the mouth may conveniently be closed with the cheek or finger.

The Holger Nielsen method

On recovering the body of an apparently drowned person you must start artificial respiration immediately. Do not waste valuable time in trying to drain the lungs, loosening clothing, or other preliminaries. It may be some time before the patient shows any sign of returning consciousness, so you should not be discouraged by the apparent lack of response.

Procedure. Place the patient face down (head lowest, if on an incline) and arrange the hands palms downwards on top of each other and the forehead resting on top of them. Do not turn the patient's head to either side: keep it facing forward and well back to ensure a clear airway. The mouth and nose must be clear of the ground. Kneel on one knee by the patient's head and put the foot of your other leg near his elbow (fig. 3–10(i)).

Put your hands on the patient's back so that the thumbs just touch, with the outside edges of the wrists near the points of the shoulder blades. Rock slowly

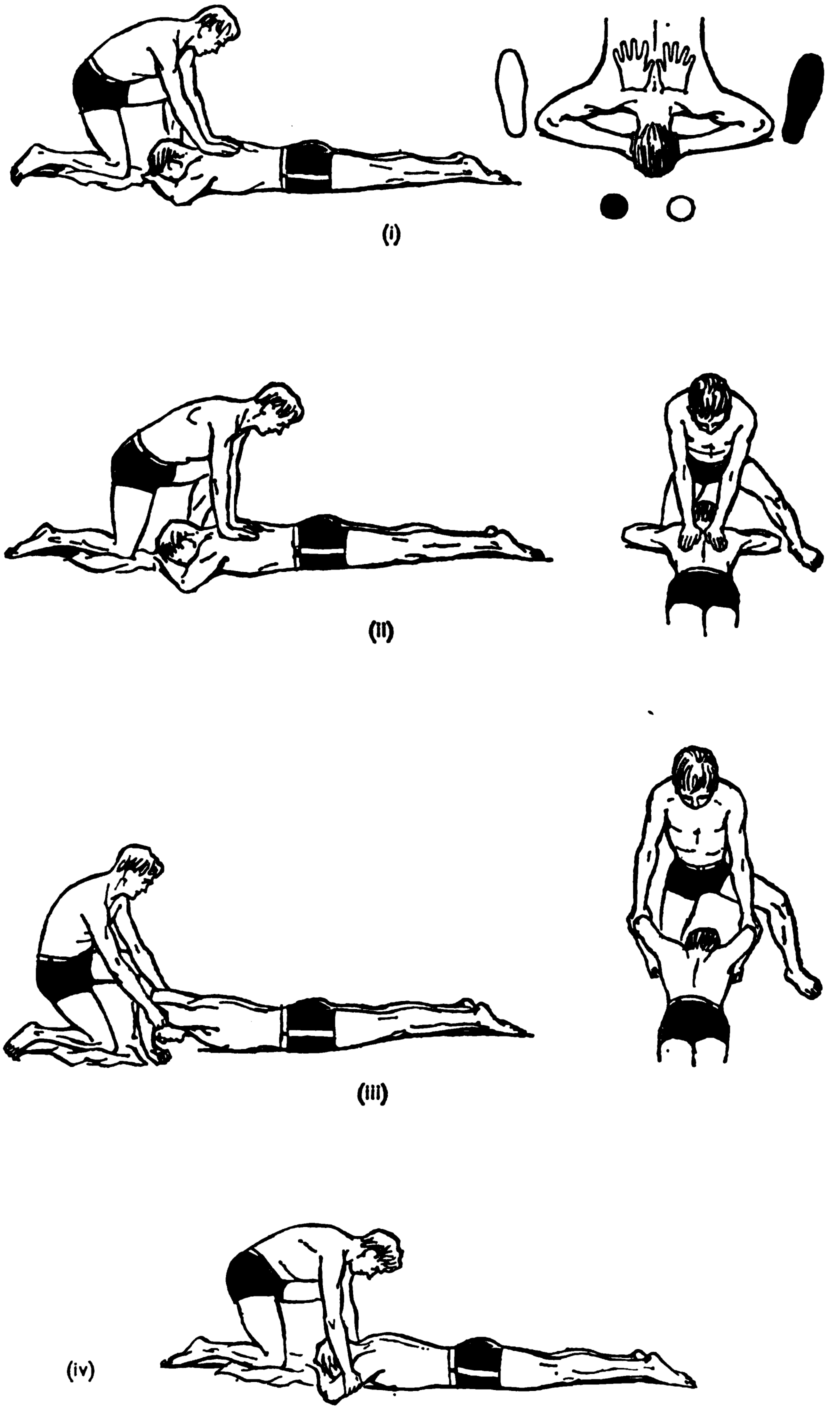


FIG. 3–10. Holger Nielsen method

forward, elbows straight, until your arms are vertical, exerting steady pressure on the chest, as shown in fig. 3–10(ii).

At the end of this movement release the pressure and slide the hands back over the shoulders and upper arms, grasping them just above the elbows (fig. 3–10(iii)). Quietly raise and pull on the arms until resistance is felt at the patient's shoulders, rocking back a little but never far enough to sit on your heel. The patient's trunk must not be raised, nor should the position of his hands and head be disturbed. Lower his arms gently (fig. 3–10(iv)) and take up your original position, as shown in fig. 3–10(i).

The cycle should be repeated twelve times a minute with a steady rhythm and even pace, and you should listen intently for the clear movement of air through the respiratory passages.

After-care

How long to continue. You must continue artificial respiration to the limit of your endurance. If the patient makes no effort to breathe spontaneously in a few minutes, it is probable that his case is hopeless. It is nevertheless worth persevering, because the return of consciousness may be long delayed, and it is very difficult to recognize the shallow respiration of an unconscious person.

Signs of life. The first sign of life may be a slight movement or a gasp, or his skin may begin to assume a normal colour. At this stage the breathing will begin to strengthen, and every care must be taken to synchronize the timing of the drill with the breathing.

Circulation. Do not attempt to promote circulation. Massage of the limbs and excessive covering only puts an additional load on the heart. The minimum covering to prevent undue loss of body heat only should be provided.

On recovery, the patient should be kept warm and quiet. Warm drinks may be given, if possible, but no alcohol. Keep the patient under close observation for at least 24 hours.

SURVIVAL ON LAND

Normally, you are advised to remain in the area of sinking, but you should try to reach land when you can see it or when you know that it is close. In higher latitudes land is usually visible from a considerable distance, but in the tropics you can be a mile or two from a small coral atoll without sighting it.

The presence of land below the horizon may be indicated by a low cloud which does not alter its position in an otherwise clear sky; or by numerous birds flying low in one direction in the evening; or by a patch of green haze in the sky, which is usually the reflection of the lagoon of an atoll in tropical waters; or by a quantity of floating wood and vegetation (which must not be confused with the refuse jettisoned by ships); or by the smell of earth and herbage.

Attracting attention

Soon after landing you should collect materials and have your liferaft distress signals ready to attract the attention of passing ships or searching aircraft. Always have a large fire built ready to light, and make a large S.O.S. sign on

the beach or open ground, using white coral rocks, coloured material, seaweed, or dark soil on a contrasting background. The fire, once well alight, can be fed with damp vegetation to produce smoke, which should contrast with the background—for example, black on sand and snow, white on vegetation. A blanket or cloth held over the smoke and released at intervals will produce an S.O.S. Morse sign that can be seen for many miles.

You will now appreciate the reason for collecting as much wreckage, clothing and personal effects as possible at the scene of your abandoning ship. Everything collected will in some way help you to exist, in either hot or cold climates, until rescued.

Tropical waters

Tropical islands are usually surrounded by coral reefs, which are often covered by dangerous surf and by breaking seas. A smooth patch in the line of breaking surf will usually indicate a passage through the reef. Coral is sharp and causes quite severe wounds which become infected and ulcerate very easily, and there is always a risk that your liferaft will be cut and torn to pieces. Before attempting to reach the more sheltered waters of the lagoon put on your life-jacket and inflate it; protect your feet and hands with boots or pieces of material; get outside the tent in case you are trapped when the raft strikes the reef or capsizes in the breakers; and recover the streamed solar stills from astern. The raft and its equipment will be needed on land. If possible, exercise patience and navigate the raft so as to get the most favourable approach for landing.

On landing, your main problem, as always, is to find a water supply. If the island is inhabited water must be available. If the island is small and uninhabited, water can usually be found or it can be produced by the solar still.

Finding water. Dig in the sand above the high-water mark, and as soon as water starts to collect in the hole taste it. If it tastes salty or brackish continue the digging farther inshore until you find water which is drinkable. Water may be present in the stems or leaves of plants or trees and there is no harm in tasting it. Any sap which is milky or tastes bitter should be left alone unless it is *known* to be safe.

It is a sensible precaution to boil all water found on an island for at least three minutes, whether the island is inhabited or not. You will not be carrying a kettle with you, but the stems of the bamboo tree are suitable. Cut off a suitable length just below a cross-partition. Fill the hollow stem with water and lay it across your fire at an angle of about 45 degrees. The water will boil before the wood burns through. If you have no utensils, water can still be boiled by dropping hot stones, heated over a fire, into rock pools or even into a fabric container let into the sand.

If water is scarce every opportunity should be taken of catching and storing rain water. The tent of the liferaft can be rigged permanently as a catchment. Take advantage of every rainstorm to store as much water as possible in every conceivable container.

Salt will be a necessary part of your diet to make your food palatable. Salt is also necessary as a food when you are sweating and drinking a lot of water. It can be made by evaporating sea water in the sun, either by soaking a piece

of canvas or heavy cloth or by filling a shallow rock depression. The residual salt crystals can then be collected.

Coconut trees are to be found on most tropical islands. When young the nuts are covered with a green husk which turns brown when the nuts are ripe. The milk is drinkable, but that in the brown nuts is very rich and creamy and is apt to cause diarrhoea. The white flesh can be eaten, and the whole tree is useful for the materials it supplies. You can make shelters and clothing from the leaves, and rope or line by plaiting together the fibres of the husks and leaves; the nut shells can be used as cups. The oil squeezed from the ripe flesh can be used to prevent sunburn or as fuel for a lamp made from an old sea shell, using a fibre wick.

Do not sleep under a coconut tree—a blow from a falling nut can be very painful, and sometimes fatal if you are struck on the head.

Dangers of lagoons. Lagoons are usually shallow and the water is clear, warm and very inviting. But dangerous fish lurk in the sand and in the hollows of the reefs and coral growths; and coral is sharp, causing sores and cuts that take a long time to heal. If you can find an inlet without coral, and if you wear boots, stay in shallow water and keep a sharp lookout, it is reasonably safe to bathe.

Camp site. In choosing a site for your camp much will depend on local circumstances; but it is fairly obvious that it should be on high ground, to windward of vegetation in order to lessen the nuisance of flying insects, some distance from the vegetation in order to avoid danger from scorpions, centipedes, snakes and landcrabs, but reasonably close to the clearing where the ground-to-air signals are displayed.

Your shelter can be either your salvaged liferaft or a structure made from bamboo stalks and plaited palm leaves. It is of the greatest importance to keep your site clean and free from scraps of food and rotting vegetation, which will attract every kind of animal and insect.

Construct a lavatory as far as possible from—and preferably to leeward of—the camp site and the water supply. It should discharge into the sea, but if this is not possible dig a deep trench and insist that all motions from the bowels be covered by sand or soil as soon as passed. Failure to do this will attract flies and other insects and may also spread dysentery.

Natives make their own tools and so must you. Shells can be made into shovels, stones tied in a split stick will make a hammer or axe. Fish-hooks and needles can be made from slivers of wood, fish spines or scraps of metal. You will have no need of weapons except for hunting. Apart from amusement it will be useful to try making bows and arrows with which to catch sea-birds. A spear with a barbed or notched end is useful for catching fish.

At night you should sleep raised off the ground at least a foot. Make a rope net from plaited coconut fibre or leaves and stretch it on supports which have been driven into the ground. The liferaft can be used temporarily if it has survived the passage through the reef and across the coral. In the morning make sure that shoes have no scorpions or other insects in them.

Natives. If the island is inhabited it will support life. Make friends with the natives and watch what they do and what they eat. Avoid close contact with them, don't sleep in their huts (which are probably bug-infested) and, above

all, leave their women alone—they carry their own brand of venereal disease and will possibly have leprosy as well. Keep to your camp site, without being unfriendly, and post a sentry to look after your equipment. Natives will always be tempted to steal if your equipment is left unguarded.

Fish in tropical waters are a palatable addition to your ration provided that they are cooked at once. But some fish are dangerous because they sting and their flesh is poisonous, while others have poisonous spines. In general, a fish that has spines, bristles or spikes instead of scales, or which inflates itself, must be regarded as poisonous. Some edible fish are ferocious; for example, there are eels up to 10 ft long that lurk in crevices under rocks or ledges of coral, whose powerful jaws can bite off fingers or toes.

Shell-fish are safe to handle, with the exception of those whose shells resemble large ice-cream cones with lids. These contain an animal whose bite is like that of a venomous snake. Any other shell-fish can be eaten if freshly boiled; to eat raw shell-fish is asking for trouble. For further details and illustrations of these fish see B.R. 1329, *Handbook for Survivors*.

Snakes, in spite of popular belief, will seldom attack you unless they are, or think they are, in danger of being trapped. They have a habit of basking in the sun and as their protective colouring makes them almost invisible it is quite easy to tread on them. Death from snakebite is rare, but the following action should be taken immediately: Apply a lightly constricting ligature (a handkerchief or cloth) above the bite, releasing it for one minute in every thirty. Wash the bite with water and immobilize the bitten part in a dependent position as for a fracture.

Scorpions and big *centipedes* can give you a severe, but not a fatal, sting. (Always examine your footwear and clothes before dressing.) The bite will be very painful and the area around it will become discoloured and swollen. You should keep the affected part cool with cold water compresses and, above all, you should rest. You may be feverish for two or three days.

Mosquitoes are a nuisance as well as being carriers of malaria. If you site your camp clear of stagnant pools and damp vegetation, and keep the site free from waste food and water, you will lessen its attraction for mosquitoes. It is always a wise precaution to cover your arms and legs after sundown.

Land-crabs of the type found on many Pacific atolls grow to a large size and can move very quickly. They attack each other and will not hesitate to attack man. Experience has shown that a loose ring of broken coconuts placed round the camp site attracts them, but they will not pass through it.

Arctic waters

In Arctic waters your main problem will be to keep warm and find food. Water should not be difficult to obtain from snow and ice and, in summer, from freshwater pools on ice floes.

Shelter. If your raft is intact it will provide you with shelter as effectively on land as afloat. Place the raft in a sheltered spot, and if possible, keep it off the snow or ice by putting moss, lichen or other soft vegetation under the floor. The inside of the raft will be even warmer if you can cover the tent with light vegetation to increase the insulation.

If you are able to light a fire, build it close to the entrance to the raft but far

enough away to avoid the risk of burning the raft, which is inflammable. A screen of logs behind the fire will reflect more heat into the raft.

Should your raft be destroyed, it is possible to build a shelter from snow blocks, igloo fashion, or a shelter may be provided by a dug-out in the snow. When constructing snow shelters adequate ventilation holes in the roof and at ground level must be provided and kept open, because intoxication from carbon dioxide occurs if the oxygen consumed is not replaced, and from carbon monoxide (which is heavier than air) if a fire is lit.

Care must be taken to brush all snow from your clothing before entering a shelter, otherwise the snow will thaw and, when you go out again, form ice which is difficult to remove. Boots and socks should be carefully dried out at night to guard against frostbite and to preserve the footwear, which is a vital part of your clothing and irreplaceable. Do not leave it unattended near a fire.

Food. A description of how to trap and kill animals for food is given in the *Handbook for Survivors.*

RESCUE

Rescue must be studied from two angles—the survivor's and the rescuer's. Each is important, but it is intended here to deal with rescue in its broadest application.

Rescue stations

These should be amidships, well clear of the propellers (and, if possible, where the freeboard is lowest) and abreast a davit, derrick or crane which can be used for hoisting men inboard. At each station there should be a number of men to work over the side of the ship or in the water close alongside, with lifelines attached to their lifejackets, actively assisting survivors to safety. The lifelines of all men working outboard must each be tended by two men. There must be men detailed to provide lifelines for the survivors and to hoist them inboard. Provision should be made for relieving the men working over the side at frequent intervals. Stations should also be allocated for providing uninjured survivors with dry clothing, warmth, hot drinks, food and rest, and for giving medical attention to the injured.

Each station should be provided with some or all of the following gear:

1. Stout lifelines for attachment to the beckets of the lifejackets of all men working outboard. The becket should be worn at the back of the head.
2. Two stout lifelines rove as whips through blocks at the head of each davit or derrick; the end of each line should be fitted with a spring hook so that it can be hooked to the becket of the lifejacket or a rescue strop, or to its own part after being passed round the survivor's waist.
3. A number of hauling-in lines, each having a large soft eye at the end and fitted with white-painted corks, so that it can be flung to a survivor, will float and can be seen at night.
4. Some form of stretcher with slings, which can be submerged sufficiently for an injured survivor to be floated over it and then hoisted on board.
5. A cargo net which can be lowered beneath the surface and then used to hoist a number of survivors at a time.

6. Ladders or scramble nets rigged to provide support for the men working over the side and for active survivors to climb.
7. Light grapnels on the end of stout heaving-lines, for casting over helpless survivors floating out of reach of the rescuers.

Recovery of men in rafts

This is effected by the ship drifting down to the raft and making a lee for it. If the survivors are active and the conditions are favourable, they should board the rescue ship by scramble net or ladder. If the survivors are distressed, or conditions are unfavourable, recovery should be made by attaching a line to the becket of the lifejacket, or by line and helicopter rescue strop. If the survivors are not able to help one another the rescue ship should put two fit men aboard the raft. Pass the recovery line through a block at the head of a general-purpose or similar davit (turned outboard about 3 ft), through a leading block on deck and keep in hand by a few men.

Recovery of raft

If it is required to recover the raft, trip the water pockets to reduce the weight and lift by the towing bridle (the attachment of the lifelines on the raft is not strong enough for this purpose). Pass a line from the 'D' ring on the towing bridle at one end of the raft through a block at the head of a davit, and thence through a leading block on deck. Similar hoisting arrangements are made for the other end. About 12 men are required on each whip.

Recovery of men from the water

Survivors will probably have little or no reserve of energy, and they will either be unable to help themselves or will expend their remaining energy in trying to climb out of the water. In the past many men have been lost while floating alongside a rescue ship because they were unable to climb up her nets or ladders, or even bend lifelines round themselves. Whenever possible, men swimming should be hoisted on board, not assisted up scramble-nets or ladders, because the latter method wastes their rescuers' time and energy; the strength and energy of five active rescuers can be taxed to the utmost in assisting an oil-covered survivor to climb up a scramble-net to the deck of a destroyer. When a ship is rolling there is a considerable surge close alongside, particularly on the lee side, which tends to draw a swimmer under the ship.

The following methods of rescuing large numbers of survivors floating in the water or clinging to wreckage have been used successfully:

1. A cargo net can be slung over the side below a pair of davits, a whip being rove through a single block at each davit head and the end bent to each of the lower corners of the net. Survivors then float over the lower end of the net and are hoisted on board parbuckle-fashion.
2. A hammock, canvas strop, bosun's chair or breeches buoy can be used to hoist injured survivors on board.
3. Boat-booms of frigates are rigged with a jackstay and an outhaul to haul out a scramble-net along the boom; when the boom is swung out the lower side of the net should be well submerged. This method is used to give a large

number of survivors something to cling to and to prevent them from drifting away from the rescue ship, until they can be hoisted or assisted on board.

4. A coir hawser can be bent to a buoy and fitted at intervals of a few feet with long beckets and cork floats. It is streamed astern so that survivors can grasp the line and put the beckets either round their waists or through the beckets of their lifejackets. The inboard bight of the hawser is snatched into a block well forward; the survivors can then be hauled alongside.
5. A line-throwing projector can be used to pass a line to an isolated survivor. The projector must be powerful enough to cast a sufficiently robust line.

Rescue of man overboard in harbour

The chances of recovering a man who falls overboard in harbour, particularly at night when the ship is anchored in a strong stream, are greater if the following precautions and actions are taken.

An inflatable lifejacket and long length of light lifeline must always be kept available for immediate use. The rescuer, who should preferably be a strong swimmer, wears the lifejacket with the becket of the webbing harness slipped over the head. The lifeline is secured to the becket, the lifejacket light is switched on and the rescuer swims to the casualty. Just before reaching the casualty the rescuer inflates his lifejacket, then grabs the casualty, turns on his back and is hauled back to the ship or held by the lifeline if the stream is too strong. Should the casualty be further from the ship than the length of lifeline before the rescuer can reach him, the ship must let go the end of the lifeline and both men must be recovered by boat.

Ship organisation

Each ship must have its own internal organisation for rescuing survivors, and the crew must be exercised in all methods of rescue. The station-bill should provide for rescuing as quickly as possible as many survivors as the ship can carry, hoisting inboard the sick and wounded, feeding, clothing and accommodating the survivors on board, and giving medical care and treatment to the sick, injured or wounded and to those suffering from shock and exposure.

Recovery of men by helicopter

It is unlikely that rescue from a liferaft will be effected by helicopter. The fact that men are in a raft will show that a major accident has occurred to their ship and it can therefore be expected that another ship will carry out the rescue by one of the methods described above. It is the swimmer who is most likely to be rescued by helicopter, and the various methods used in such a rescue are described below.

By helicopter rescue strop. This is a double-ended padded strop hooked to the helicopter winch wire and lowered from the helicopter to the swimmer. The method of entry into the strop, shown in fig. 3-11, is as follows:

1. Grasp the strop with both hands.
2. Place the strop over your head and behind the lifejacket.
3. Release one hand and insert the arm through the strop, followed by the other arm.
4. Get the strop comfortably under the armpits; then pull down the webbing

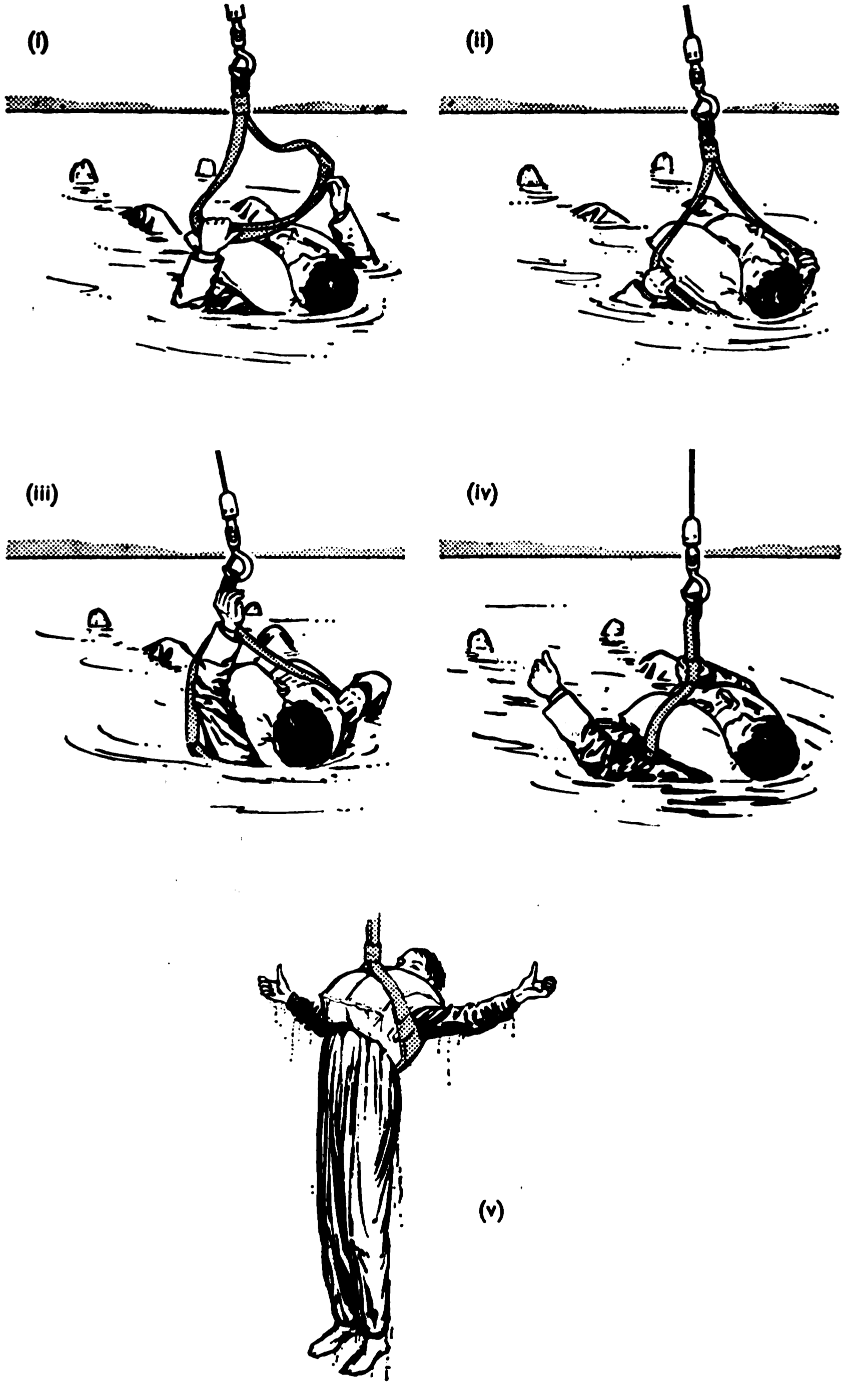


FIG. 3–11. Helicopter rescue strop

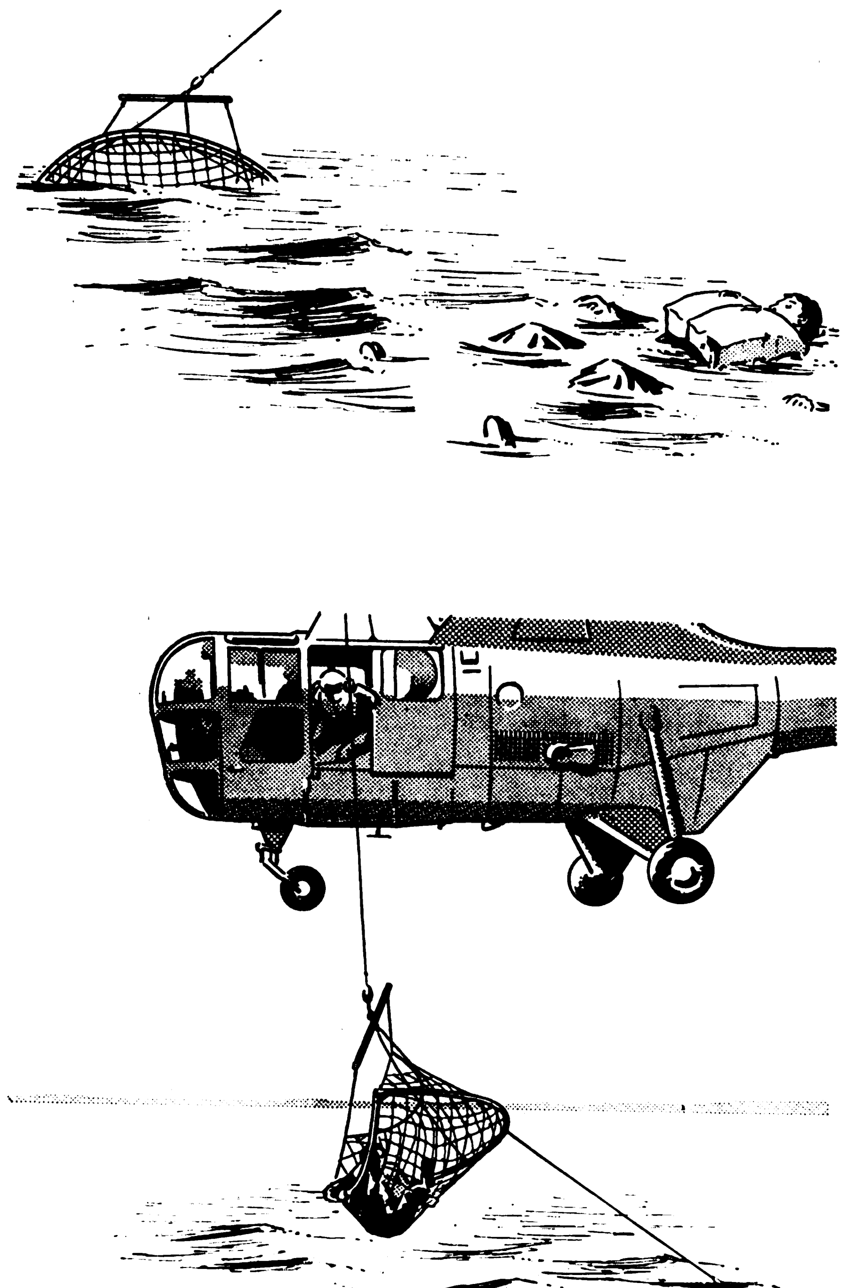


FIG. 3-12. Helicopter rescue net

band from the top eyes of the strop until the loop of the strop is small enough to prevent your slipping from it.

5. Stretch your arms sideways, keeping them horizontal. Then give the helicopter crewman the thumbs-up sign to tell him that you are ready to be hoisted clear of the water.

By helicopter rescue net (fig. 3–12). This is a net lashed to a light but strong frame and lowered into the water from the helicopter. It is trawled through the water until the swimmer is scooped up. This method recovers a man more quickly and is used either when it would be dangerous to lower a crewman to the swimmer or when the swimmer is injured or unconscious.

By helicopter double rescue harness (fig. 3–13). This rig is designed for lowering a crew member from the helicopter into the water. He passes a strop round the swimmer, and then both men are hoisted together. This method is used when the swimmer is in difficulty or injured.

FIG. 3–13. Helicopter double rescue harness

TREATMENT OF SURVIVORS

The care and treatment a survivor will require after rescue depend largely on the climate, the length of time he has been adrift, and any ill-effects caused by exposure. Survivors in tropical climates will probably be suffering only from lack of water and nourishment, and perhaps from sunburn, boils and sores. In very cold climates, however, they usually perish from the effects of exposure long before their bodily health is broken down, and when rescued after being adrift for any appreciable time they may be suffering from cold, frostbite or immersion foot. In general, the common remedies advocated in first-aid handbooks should be applied, but some advice is given here on how to treat those ailments peculiar to survivors from shipwreck.

Food and drink

A good drink, hot or cold, is one of the first things required. Any non-alcoholic drink will do; and no harm can result, however much is drunk, if at first it is taken only in small quantities at a time. The worst that can occur from taking too much to drink is vomiting. At first only light and easily digestible food should be given, such as bread and milk or a bowl of thick soup. Gradually a return to more solid food can be made, but too heavy or too large a meal may lead to indigestion. There is no cause for worry if constipation occurs for a few days.

Exposure

Survivors rescued straight from the water are more likely to suffer from the effects of cold than those from lifeboats or rafts. When the temperature of the water is below 40°F men are liable to succumb within three hours, but many instances are known of survival after considerably longer periods in water at such temperatures. The chances of survival are much greater when the temperature of the sea is higher, and in tropical waters men have survived after being adrift in the sea or in floats for many days.

If a man feels particularly cold, or if he is shivering and his teeth are chattering, he should be warmed up by giving him hot drinks and putting him in a warm place; but if he is very pale, lethargic, numb, collapsed or unconscious through exposure to extreme cold (a probable state if his rectal temperature has fallen below 80·6°F) he must be warmed immediately and rapidly.

If he is unconscious he should be undressed immediately and placed in a hot bath at a temperature of 110°F for not longer than ten minutes, then dried with a towel and placed in warmed blankets. If his temperature does not then rise by at least 2°F every ten minutes the treatment should be repeated until his rectal temperature rises to about 93°F. Once his temperature has risen to the safe level of between 91° and 93°F he is out of immediate danger, and rapid heating by immersion should be stopped, otherwise he may be scalded; instead he should be kept warm under hot blankets. If a bath is not available, hot water at a temperature of from 115° to 120°F should be poured over his clothes, up his sleeves and trousers and down his neck. Rapid heating can be very painful, and if the man is conscious a maximum bath temperature of 105° will probably be as much as he can stand.

Another method of rapid heating, which is almost as effective and probably more suitable for treating a number of survivors, is to put them in a hot, damp atmosphere similar to that of the steam room of a Turkish bath. Such an atmosphere might be produced by admitting steam to a bathroom, or failing this, the men could be taken to a particularly hot place in a boiler room or engine room.

Survivors who have been exposed to moderately cold temperatures for long periods should not be rapidly heated, but should be warmed slowly with hot-water bottles, electrically-heated blankets or light-cradles. Massaging, drugs and alcohol should be avoided.

Frostbite

The conditions which cause frostbite, and also its symptoms, have already been described on page 60. The best way of thawing out the affected part is to put it in *cold* water while keeping the rest of the patient's body warmly wrapped up. On thawing, the skin will at once soften and quickly become pink or red. Any kind of massage, and rubbing with snow or any other substance, is dangerous.

If pain is severe on thawing, cool the affected part again for a little while with cold water, ice or snow. After thawing, warming up must be very gradual; it is dangerous to apply hot water or hot-water bottles, or to warm the affected part in front of a fire.

Clean and dry the affected part as gently as possible, dust it carefully with sulphonamide powder, then wrap it in clean material and see that it is kept absolutely resting. Blisters or other breaks in the skin should only be opened by a doctor, otherwise complications may set in.

After initial treatment the body should be kept warm and the injured part clean, and the patient should be given a hot meal.

Immersion foot

The conditions causing immersion foot, and the symptoms of this complaint, have been described on page 60. Treatment must begin immediately after rescue.

As soon as the patient arrives on board all his clothes should be removed and he should be wrapped in warm blankets. Hot bottles may be placed between the blankets, near his body, but not near the affected limbs, which should always be kept cool. The limbs may be cooled by the use of fans, and even ice if necessary, but no ice should be allowed actually to touch the skin. While it is desirable that the temperature of the skin be reduced to about 80°F, it is highly undesirable that it should be reduced much below 70°F; the skin temperature should therefore be taken frequently by placing a bath thermometer against the skin under a light covering of cotton wool. The limbs will swell again if allowed to warm up too quickly, and they should be handled very gently; heating or rubbing them in any way is harmful. The treatment should be continued until all swelling has gone and the patient is able to walk without pain, or until he comes under the care of a doctor.

All blisters, open sores or darkened areas of skin should be dusted with sulphonamide powder and covered with clean, dry cloths. The feet and legs

should be kept quite dry, and no lotions, ointments, or antiseptics other than the powder should be applied.

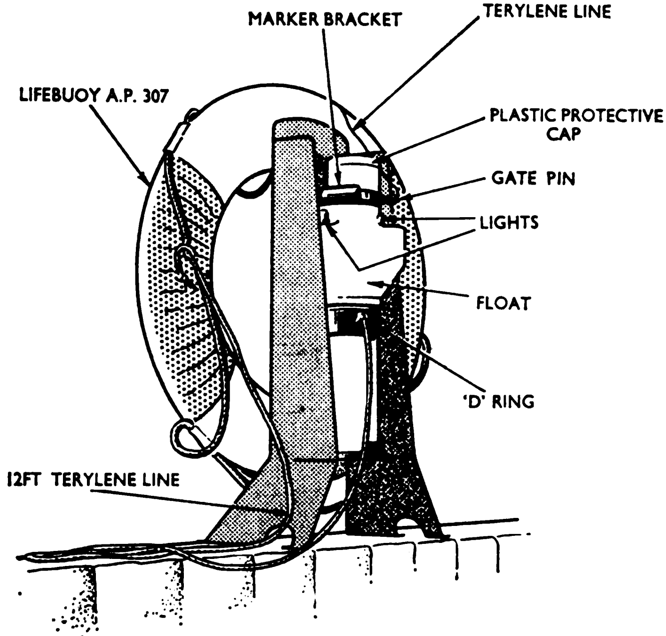


FIG. 3–14. A.P. 307 lifebuoy and 'Manoverboard' smoke and light marker

LIFEBUOYS

The lifebuoy (A.P. 307) illustrated in fig. 3–14 is the type provided in the Royal Navy. It is made of solid cork or expanded plastic covered with canvas and is fitted with a lifeline which is secured to it in four places to form four easily-grasped beckets; these should never be stopped together at the centre of the buoy (as is often done for the sake of appearances), because this will prevent a man in the water passing his head through the buoy.

Lifebuoys should be inspected frequently and tested at regular intervals. They should not have too many coats of paint, as the weight of the paint will reduce their buoyancy.

In all ships two of these buoys are placed aft, one on each side of the ship and under the charge, when at sea, of a lifebuoy sentry; and two are placed on the bridge, one on each side (except in aircraft carriers, where there is only one—to starboard). In all larger ships, except carriers, a third pair is carried amidships.

Manoverboard smoke and light marker

This device (fig. 3–14) consists of a tube containing a smoke composition

which gives off a dense, orange-coloured, non-toxic smoke for a minimum period of 15 minutes. It is ignited by a sea cell at the bottom of the tube, supported by a concentric plastic float on top of which are two electric lights supplied from sea cells fitted inside the float. The minimum burning time for the lights is 1½ hours. The marker and lifebuoy are mounted together, with the lifebuoy inboard and the marker outboard, and are connected by a 6-ft length of Terylene line.

To release the lifebuoy and marker, lift and pull the metal tag marked 'Instruction Tally plate'; then throw the lifebuoy overboard with as much force as possible. The line jerks the marker from the 'gate'-type bracket, and the orange Courlene lanyard attached to the bracket jerks out the plastic sea cell plugs on the tube and float, thereby allowing sea water to enter the sea cells when the marker hits the water. The smoke candle and lights should operate within 3 seconds of entering the water.

This marker should only be used operationally and not when exercising seaboats.

Smoke and flame marker

This marker is designed for exercise purposes only, in particular for exercising seaboats. It consists of a cylinder with a brass screwed cap at each end which must be removed before launching. It gives off a greyish-white smoke (which is slightly toxic) and a bright flame for 15 minutes, after which the marker sinks. It is dangerous to use this marker when the sea surface is covered with oil or petrol.

Communication with sentry

There is direct telephone communication between the bridge and the lifebuoy sentry. There is also an electric rattler by the sentry which is operated from the bridge in accordance with the following code:

one ring: Cast overboard the starboard lifebuoy
two rings: Cast overboard the port lifebuoy
three rings: Cast overboard both lifebuoys

Man overboard

When the alarm is given the lifebuoy or lifebuoys should immediately be thrown clear of the ship.

The simplest way to get into a lifebuoy in the water is to place both hands on the side nearest you; your weight will then force this side down and lift the further side, thus enabling you to insert your head and shoulders. Then, resting your arms on the sides, you will find yourself supported with your head and shoulders clear of the water, and if you remain steady in such a position you can remain afloat for any length of time.

PART II

SEAMANSHIP

CHAPTER 4

Advanced Rope Work

In Volume I the seaman was introduced to bends and hitches, general rope work, and the details of all ropes and their usage. This chapter is a continuation of the subject of rope work and is divided into four sections, as follows:

Advanced splicing of cordage
Knots, and general advanced work in cordage
Advanced work in wire rope
General remarks on wire rope.

The information contained within each section will enable the young seaman to advance in this particular field of seamanship. The construction of the more advanced types of knots, while of little material value in the modern man-o'-war, is an art in itself and should be the hallmark of the modern seaman, as much as it was in the days of sail.

Every seaman must be able to splice a rope, to handle and to understand the rope with which he works, and to manufacture from rope the piece of rigging which is required for a particular task.

Rope tables, formulae and factors of safety are given in Appendix I.

ADVANCED SPLICING OF CORDAGE

Cut splice (natural and man-made fibre cordage)

Whip each rope at a distance from its end equal to five times the circumference of the rope, then unlay it to the whipping and whip the end of each strand (fig. 4–1). Place the ends of the two ropes alongside and overlapping each other, and stop them together. Tuck the unlaid strands of both ropes as for an eye splice and finish off either by dogging the strands or by tapering, worming, parcelling and serving the strands, as described in Volume I.

This splice is used when it is required to make a permanent eye in the bight of a rope.

Long splice (natural cordage only)

The principle of the long splice (fig. 4–2) differs radically from that of the short splice. One strand from each rope is unlaid, and one from the other rope is given a twist and laid up in its place; the remaining strand from each rope remains in the centre, resulting in three pairs of strands spaced equidistantly along the married ropes. One-third of the yarns is now taken out of all strands (not shown in fig. 4–2(iv)) and, though discarded, these yarns should not be cut off until the splice is completed. Each pair of strands is then tied in an overhand knot (left over right for a right-handed rope), and each strand is tucked over one strand and under the next, as for a short splice. Half of the yarns in each strand are now taken out and the remaining yarns tucked once more, to give

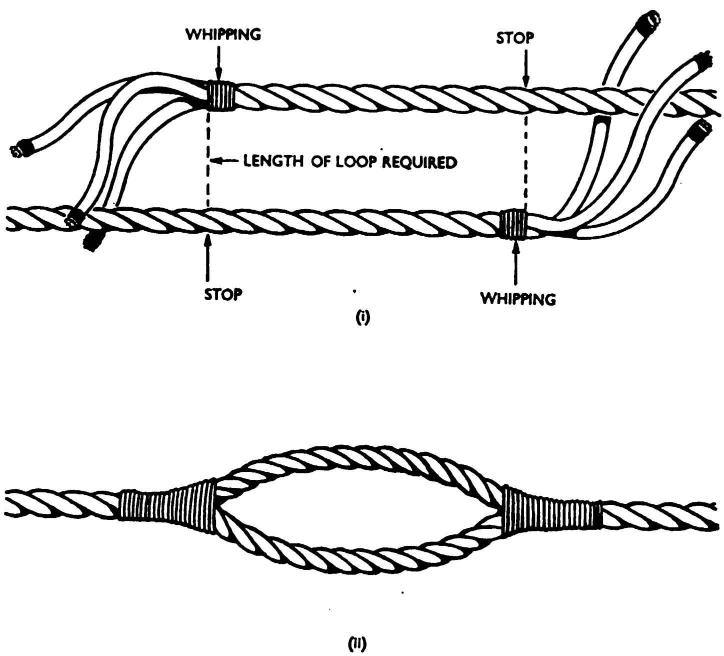


FIG. 4–1. Making a cut splice

a gradual taper (fig. 4–2(v)). The splice is finished off by stretching it, hauling taut all ends (including the discarded yarns) and then cutting them off.

To make a long splice whip each rope at a distance from its end equal to twelve times the circumference of the rope, then unlay the strands to the whipping and whip their ends. Marry the two ropes together, as in a short splice. Each strand unlaid as described above is followed up by the strand from the other rope which lies on its right in the marriage, so that H is unlaid and followed up by E, D is unlaid and followed up by F, and C and G remain at the marry. Each strand is unlaid until the length of the end of the strand following it up is reduced to four times the circumference of the rope. In splicing a 2-inch rope, for example, H is unlaid until 8 inches of E remains, and D is unlaid until 8 inches of F remains. The splice is now finished off as described above.

This splice is used to join two ropes together which are required to pass through a block. A well-made splice will not increase the diameter of the rope nor reduce the rope's strength.

Chain splice (natural cordage only)

Prepare the rope as for an eye splice, but do not place a whipping round the rope, and unlay the strands rather more than for an eye splice. Then unlay one strand, A, for another 6 inches, or twice the intended length of the eye (fig. 4–3(i)). Now pass strands B and C through the link on the end of the chain and marry up with A, thus forming the eye (fig. 4–3(ii)). Then further unlay strand A and lay up B in its place for about 12 inches, and finish off these two

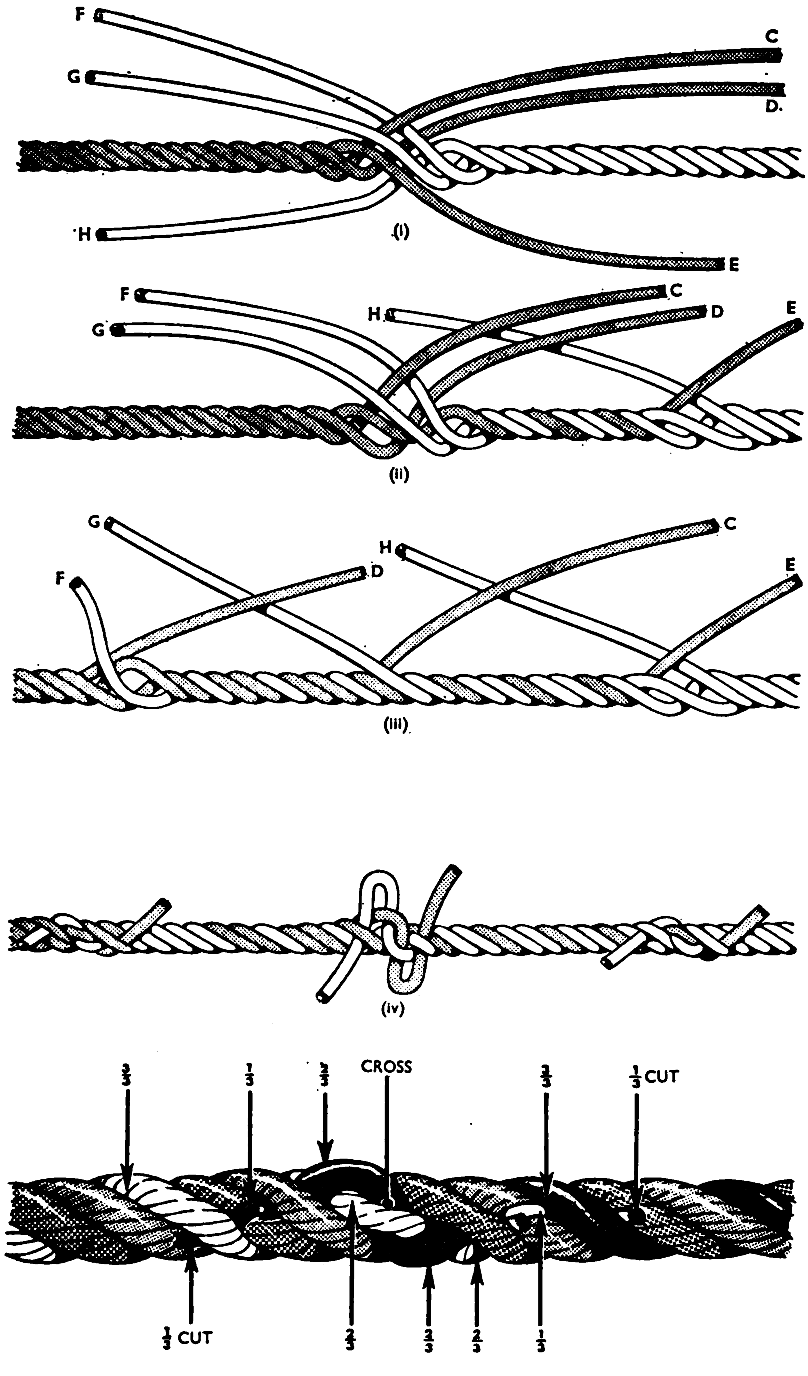


FIG. 4–2. Making a long splice

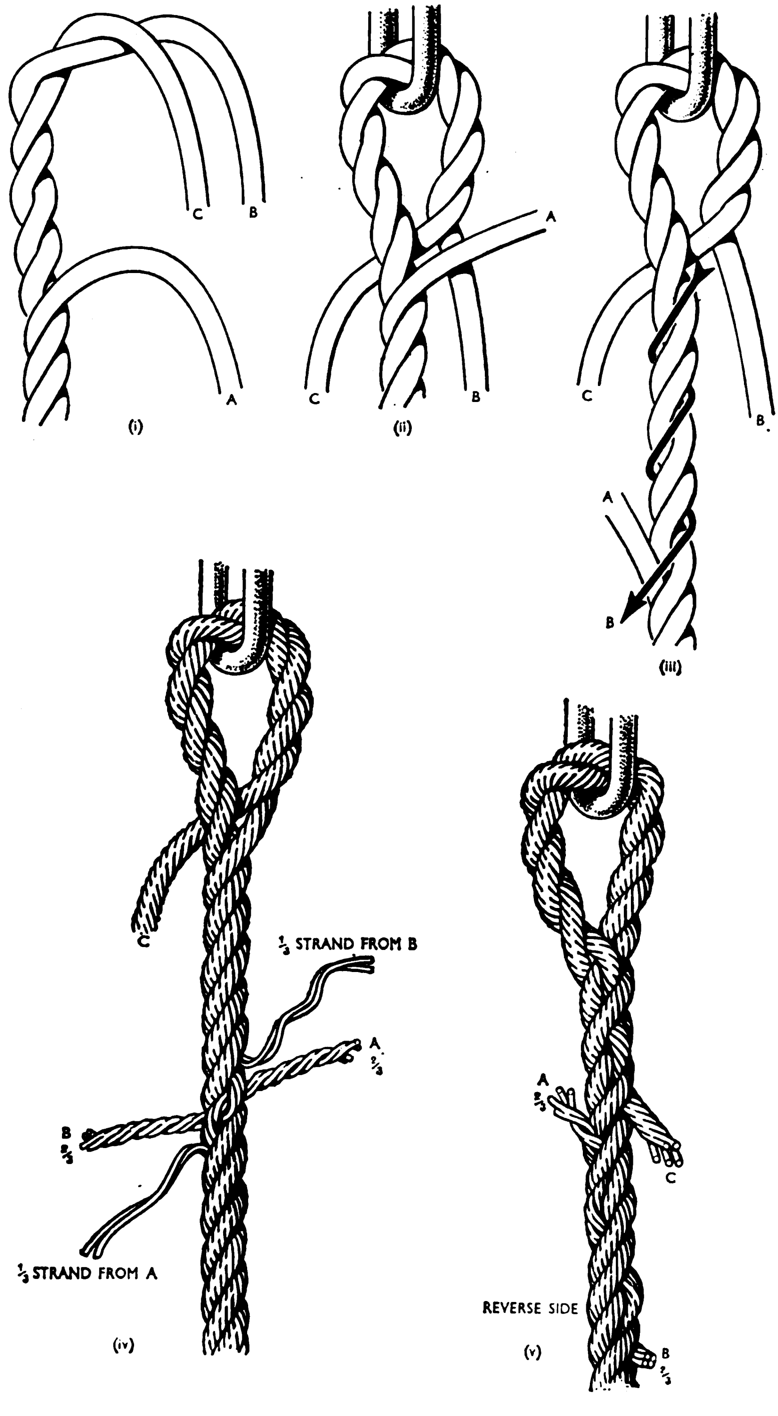


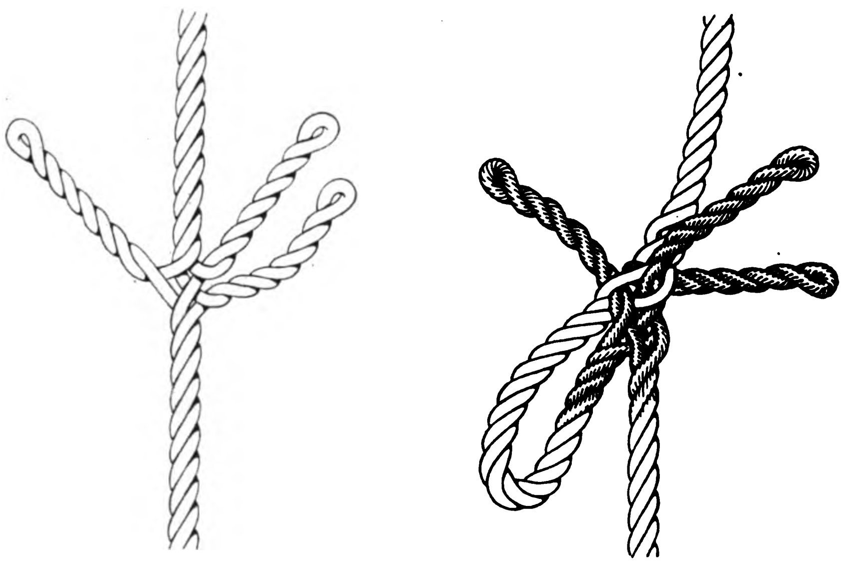
FIG. 4–3. Making a chain splice

strands as for a long splice (fig. 4–3(iii) and (iv)). Now tuck strand C into the standing part below the eye as for a short splice, with about three tucks, so as to meet strand A (fig. 4–3(v)). All ends are then hauled taut and cut off; the one-third strands of A and B are not shown in fig. 4–3(v).

This splice is used for splicing a cordage tail into a chain which is required to be led through a block or fairlead. Its strength is not more than two-thirds the strength of the rope.

To splice an eye in the bight of a rope (natural cordage only)

At the position where the eye is to be made untwist the rope to form a crow's foot (fig. 4–4(i)). Continue to untwist the rope and at the same time lay up each part of the crow's foot in its natural lay until each part is long enough for splicing. Bend the rope into an eye and tuck the twisted strands as in an eye splice (fig. 4–4(ii)). The splice is finished off either by dogging the strands or by tapering them off.



(i) (ii)

FIG. 4–4. To splice an eye in the bight of a rope

Flemish eye (natural cordage only)

Whip the rope at a distance from its end equal to three times the intended circumference of the eye. Now unlay the strands and then the yarns, select the number of inside yarns necessary to make the eye the required size, and stop the remaining yarns back on the rope.

Take a fid or circular billet of wood equal in diameter to that of the inside of the eye, and secure stops along it (fig. 4–5(i)). Then divide the yarns selected for making the eye into half, one-half each side of the fid, and overhand knot

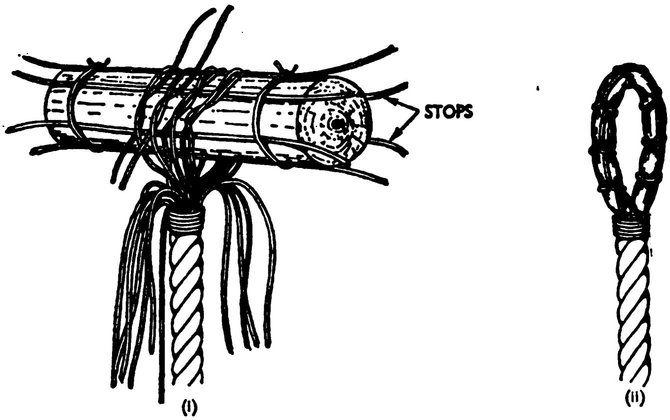


FIG. 4–5. Making a Flemish eye

them in pairs over the fid; each pair should be knotted at different parts of the fid, thus placing the knots all round the eye. Now free the stops on the fid and secure the eye temporarily in position with them. Then remove the fid, cut away the unwanted ends, taper the outside yarns and lay them up the eye, then marl down (fig. 4–5(ii)). Finish off by ringbolt hitching or cockscombing the eye as described later in this chapter.

Rope grommet (natural cordage only)

Cut a length of rope equal to three and a half times the circumference of the grommet required and then unlay the strands, being careful not to disturb their lay. Each strand will make one grommet, a right-handed grommet from a right-handed rope.

Take one strand and close it up in the form of a ring of the size required (fig. 4–6(i)) and then pass the ends round and round in their original lay until all the intervals are filled up (fig. 4–6(ii)). Finish off as in a long splice (fig. 4–6(iii)).

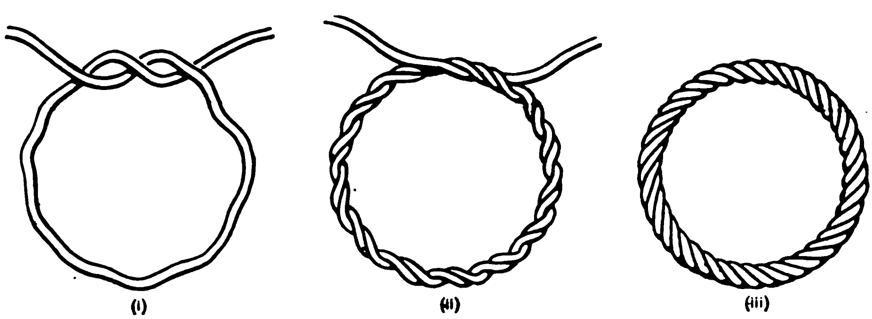


FIG. 4–6. Making a rope grommet

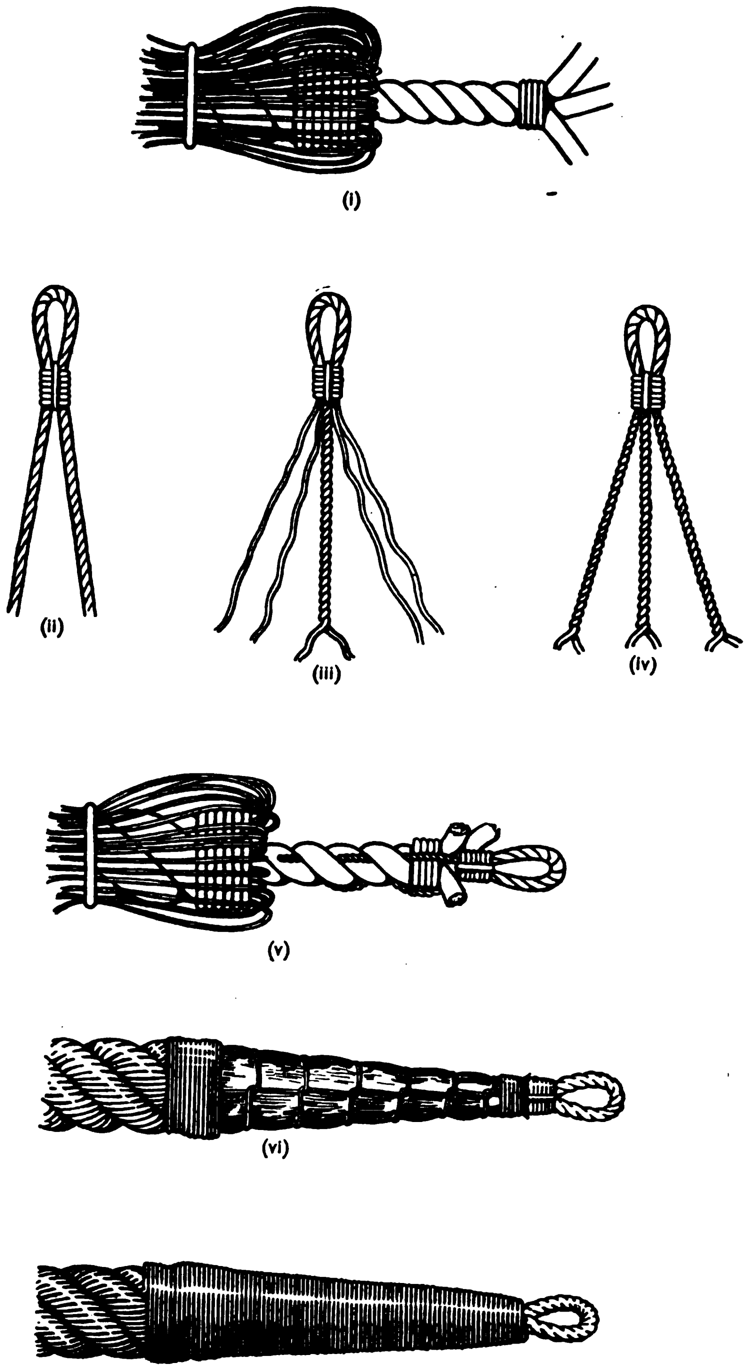


FIG. 4–7. Fitting a becket to a rope's end

To fit a becket to a rope's end (natural cordage only)

Whip the rope at a distance from the end equal to three times its circumference, and unlay to the whipping. Select approximately one-fifth of the inside yarns from each strand, and stop the remainder back along the rope (fig. 4–7(i)). Then lay up the inside yarns of each strand in the following manner. Hold the rope in the left hand, or in a vice, with the end pointing to the right. With the right hand take the farthest strand and twist it up in the direction away from the body, then bring it forward and lay it across the top of the other two strands. Hold the cross with the left thumb, repeat with the now farthest strand and continue this cycle until the three strands have formed into a rope (fig. 4–7(i)). Place a whipping on the relaid strands at a distance from their roots equal to one and a half times the circumference of the rope. The end portion of the relaid strands need not be whipped and can be left for the present (fig. 4-7(i)).

The rope which will form the becket should be one quarter the circumference of the large rope or slightly larger (1½-inch rope makes a good becket for a 4-inch rope); its length should be six times the circumference of the larger rope. Middle the small rope and put on a twine seizing so as to form an eye with two legs hanging from it (fig. 4–7(ii)); then unlay the strands in each leg to the seizing (fig. 4–7(iii)). Lay up the strands in pairs, each pair consisting of one strand from each, thus making an eye with three legs (fig. 4–7(iv)).

Now marry the three legs of the becket to the relaid strands of the large rope and tuck twice as for a short splice, but leave the whipping in place. Cut off all ends, give the splice a twist to harden it up, and marl down (see fig. 4–7(v), in which the marling is not shown). Select sufficient outside yarns from those stopped back on the large rope to cover the splice, and cut away the remainder. Then marl down, cutting out a few inner yarns after each couple of turns of marling so as to produce a neat taper (fig. 4–7(vi)). Finally serve over, beginning at the end and close to the becket (fig. 4-7(vii)).

Splicing braided or plaited cordage

Certain types of ropes, i.e. log lines and signal halyards, are of plaited construction. It would be possible for the individual strands of the plait to be unlaid, and separately tucked into the standing part of the rope, but this would be a lengthy and tedious process, and the following methods have been evolved to enable speedy and efficient splices to be made.

Hollow-centred ropes. Taper the end of the rope down to a point by scraping with a sharp knife for a distance of 1½ inches. Thread a needle with seaming twine and marl down the tapered portion, finishing off with a clove hitch. Insert a small spike into the hollow centre of the rope at the point of marrying for the eye, letting the spike emerge 2 inches away from the point of entry (fig. 4–8(i)). Withdraw the spike and insert the needle, pulling the tapered end of the rope through the centre and out at the surface of the rope. Cut off the tapered end, leaving half-an-inch to lay along the rope; then put two locking stitches through the standing part of the rope, finishing off with a clove hitch with the twine (fig. 4–8(ii)).

Signal halyards of Terylene have a heart of more or less parallel fibres surrounded by a flexible, plaited, protective covering. To splice an Inglefield clip into the halyard the heart must be secured, because it is the load-bearing part of the rope.

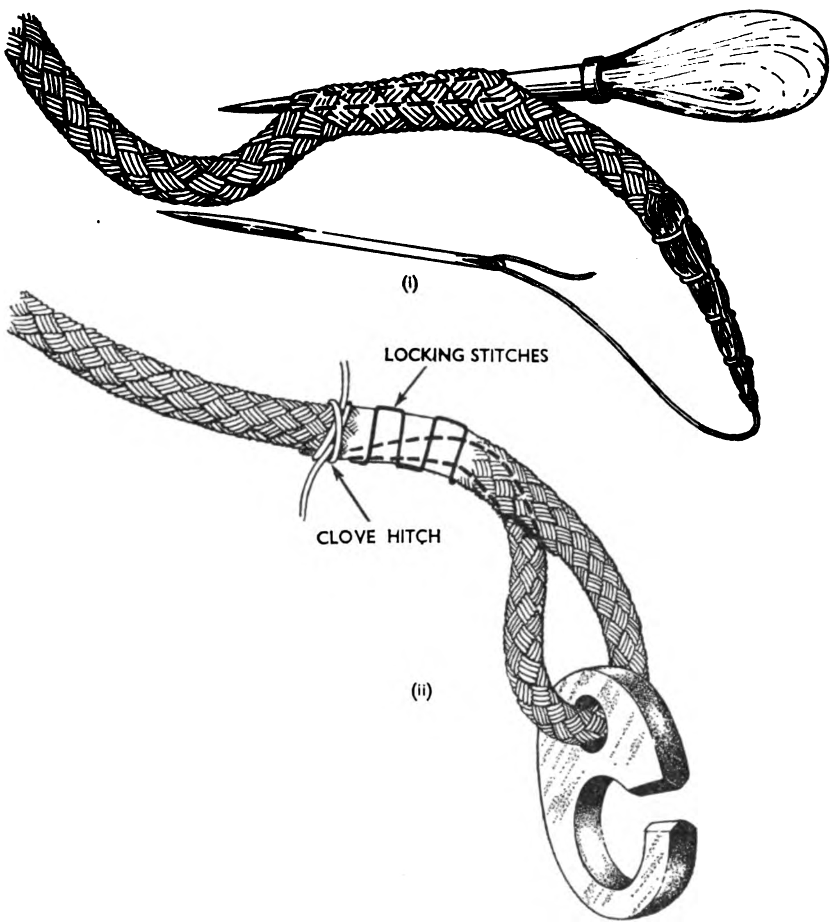


FIG. 4–8. Splicing braided or plaited cordage—hollow-centred ropes

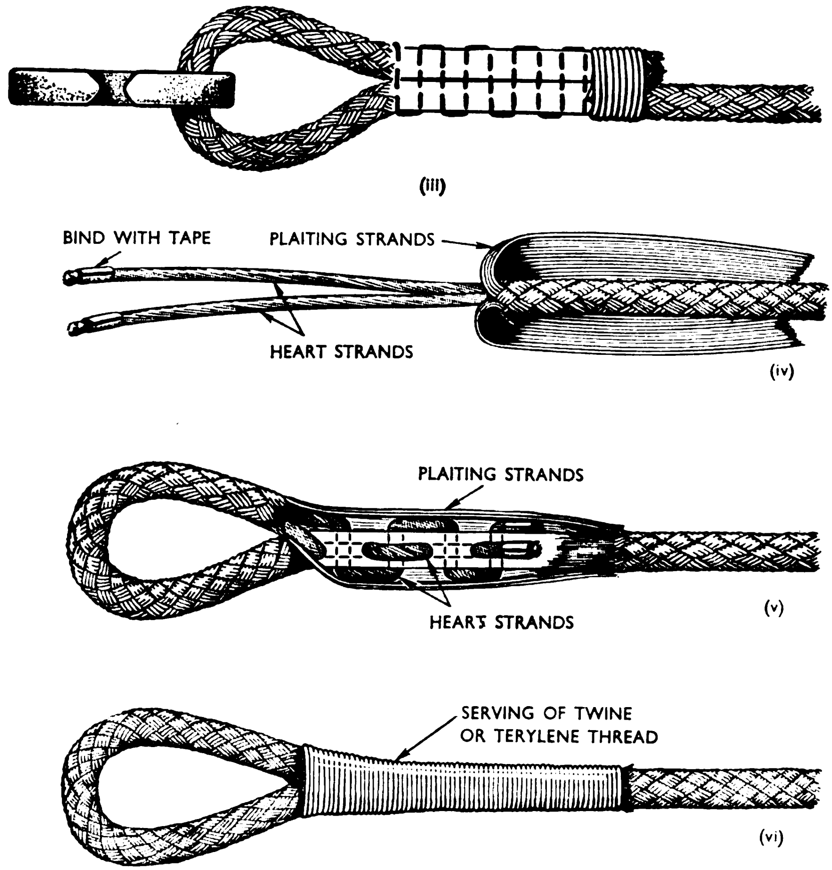


Fig. 4-8 (*cont.*). Splicing signal halyards of Terylene

METHOD A. Pass the end of the rope through the Inglefield clip and secure the end to the standing part by stitching through both parts with seaming twine for a distance of 2 inches; then further secure with a seizing (fig. 4–8(iii)).

METHOD B. Unlay the plaited sheath of the rope for a distance of approximately 4 inches. Divide the heart fibres into two strands; lay up and secure them with adhesive tape (fig. 4-8(iv)). Pass the strands through the standing part of the rope at least twice in each plane, using a spike inserted between the intersections of the plaited covering at the point where the splice is required (fig. 4-8(v)). The ends of the unlaid plaiting and the projecting heart strands are then laid along the rope, tapered down, and served over with twine (fig. 4–8(vi)).

Difficulty may be experienced in passing heart strands through the rope, because of the tightness of construction. This may be overcome by sliding the plaiting back over the heart to give a looser structure at the point of splice. After heart strands have been threaded through, the plaiting may be pulled back over the heart. The strength of this splice is 60 per cent of that of the rope.

KNOTS, AND GENERAL ADVANCED WORK IN CORDAGE

KNOTS

The functions of a knot are to prevent a rope from unreeving through a block or bullseye, or to provide a handhold, a weight or a stopper on any part of a rope. Most knots today are used only for decorative purposes.

To assist in describing how these knots are made, the strands are here lettered A, B, C, etc., and their respective bights *a*, *b*, *c*, etc.

Manrope knot

This is a decorative knot made at the ends of gangway manropes to prevent them unreeving, and to afford a handhold for anyone climbing aboard. To make the knot whip the rope at a distance from its end equal to six times its circumference, unlay the strands to the whipping, and whip their ends. Make a wall and crown (see Volume I), keeping the knot fairly loose (fig. 4–9(i)). Then

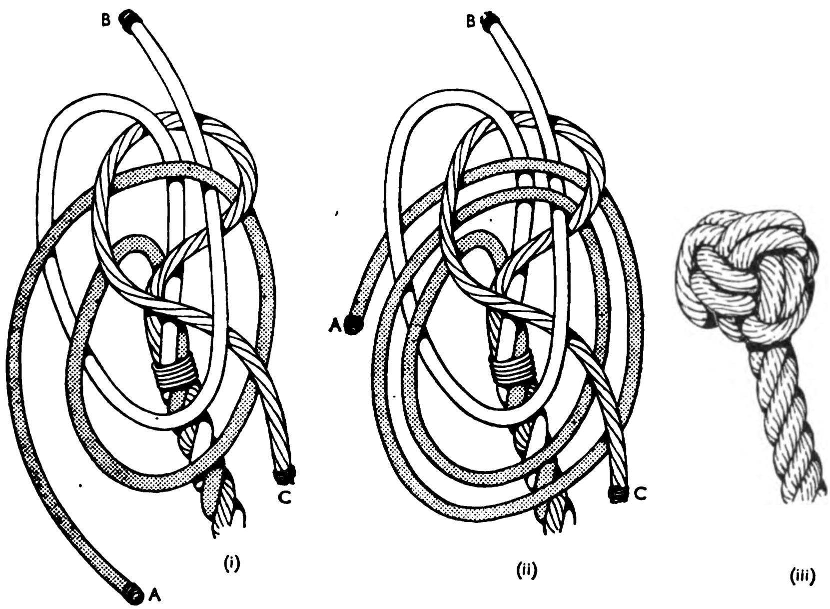


FIG. 4–9. Manrope knot

take strand A and follow it round its own part, thereby doubling up strand A (fig. 4–9(ii)). Work the other two strands similarly, haul all parts taut, and cut off the ends where they protrude from the base of the knot (fig. 4–9(iii)).

Turk's head

This is an ornamental knot supposed to resemble the turban once worn in Turkey, and should consist of three or more parts followed round two or more

times. It may be made either as a standing or a running knot, according to whether it is to be fixed to an end or a bight, or is to be formed round another part of rope, a stanchion or an oar, for example. Five different forms of this knot are described below.

FIG. 4–10. Standing Turk's head

FIG. 4–11. Running Turk's head

Standing Turk's head, made at the end of a rope. This is a manrope knot, but the ends are followed round a third or fourth time. Before starting the knot, however, the strands must be unlaid for a distance of not less than eight times the circumference of the rope. (See fig. 4-10.)

Running Turk's head, made at the end of a rope and round its own bight (as in a running lanyard), is similar to a standing Turk's head made at the end of a rope, except that the wall and crown with which it is begun are made round the bight of the rope. The strands are then followed round twice or more, thereby forming a knot which will slide up and down the bight. (See fig. 4-11.)

Standing Turk's head, made on the bight of a rope. This is formed from a three-parted length of line called a 'spider', which is tucked into the centre of the rope so that its parts emerge from the strands equidistantly. The spider is made up by tucking a length of line into the bight of another line (fig. 4-12(i)). The length of each leg should not be less than five or six times the combined circumferences of the rope and line. Having inserted the spider (fig. 4–12(ii)), crown the ends round the rope left-handed (fig. 4–12(iii)), and then turn round and crown them back right-handed (fig. 4–12(iv)). Now follow each part round with its own end two or more times (fig. 4–12(v)), work all parts taut, and cut off the ends.

Running Turk's head, made round a bight of rope, a stanchion or other fitting is formed out of a single length of line. A half-hitch is made round the rope or fitting, and then followed by a round turn; the end is then dipped under the

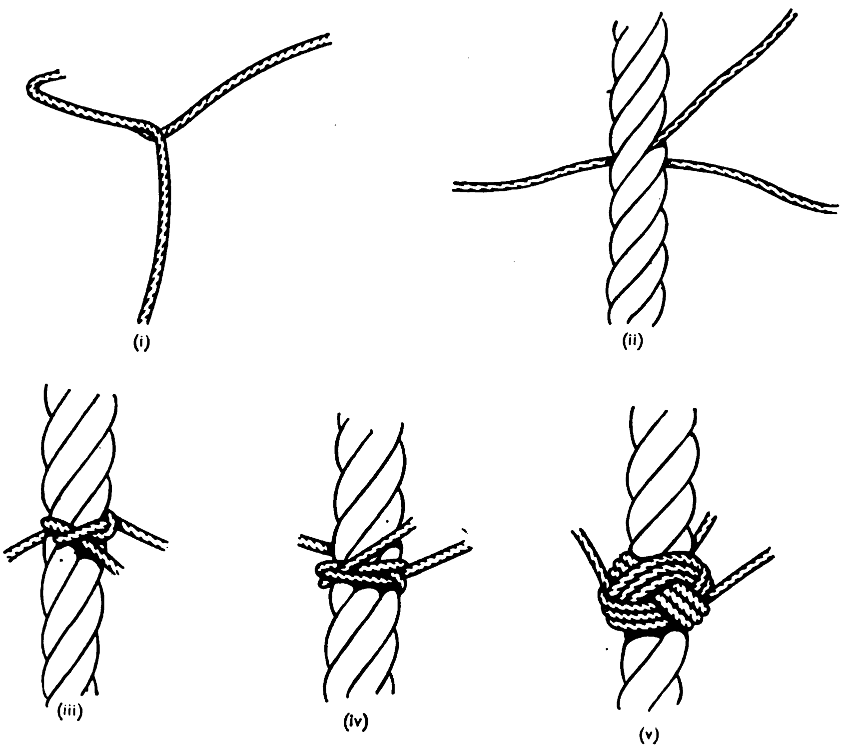


FIG. 4–12. Standing Turk's head on a bight

bight of the half-hitch (fig. 4–13(i)). The bights round the rope are crossed, the bight which is on the same side as the end of the line being placed underneath. The end is then passed down between the bights (fig. 4–13(ii)) and brought over the other side.

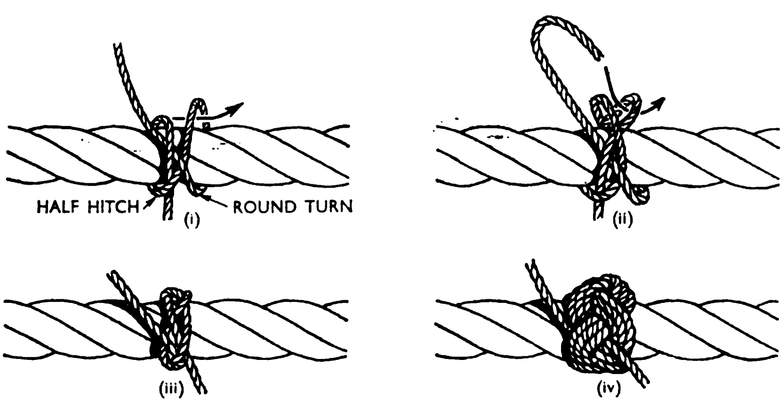


FIG. 4–13. Running Turk's head on a bight

The second and third operations are repeated until the rope is encircled (fig. 4–13(iii)). The ends are then followed round as often as may be required, all parts are hauled taut (fig. 4–13(iv)) and the two ends finished off with a crown and wall.

Multi-parted Turk's head. The running Turk's head just described has three parts only, but one of four or more parts is a simple development of the same principle.

A multi-parted Turk's head is started, as before, with a half-hitch and round turn; in other words, two turns are taken round the object to be decorated, the end passing once over and once under the standing part (or non-working end). To make a four-parted Turk's head a third turn is now taken, the end passing over the standing part. A fifth part can be obtained by a further turn, the end going under the standing part; and this can be continued—the end passing alternately over and under the standing part—as often as is required. The end is now rove back through the turns the opposite way to the standing part. It is passed alternately over and under (or under and over), so as to keep on the opposite side of each turn to the standing part, under which it finally dips. The bight of the turn under which the end now passes is dipped under its neighbour, and then alternately over and under successive turns to emerge on the opposite side of the knot. Finally the end is rove in the same way, but keeping on the opposite side of each turn to the bight.

These running Turk's heads can be made round the hand and formed into a spherical knot—at the end of a heaving line, for example.

Single Matthew Walker knot

This knot is used to prevent a rope, such as a rudder lanyard, from unreeving. It is a development of the wall knot, is neater and more decorative than the wall and crown, and is easily made.

Make a wall knot and then bring each strand up through the bight immediately on its right. Haul all the strands taut and form the knot (fig. 4–14). The strands may be either whipped together and the spare rope cut off, or, if the cordage is of natural fibre, twisted up to form the original rope.

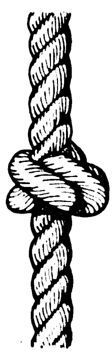


FIG. 4–14. Single Matthew Walker knot

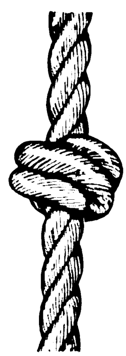


FIG. 4–15. Double Matthew Walker knot

Double Matthew Walker knot

Make a single Matthew Walker and then bring each strand up through the bight immediately on its right. Haul taut and finish off as required (fig. 4–15).

Stopper knot, or double wall

As this knot produces a more pronounced shoulder than any of the others (fig. 4–16), it forms a useful stopper on a rope to prevent anything passing beyond it. It is not so neat in appearance as some of the other, similar, knots because the ends of the strands protrude from the top of the knot; but it can be made on the bight as well as on the end of a rope and is often used in guest warps in place of the Double Diamond, described on page 98.

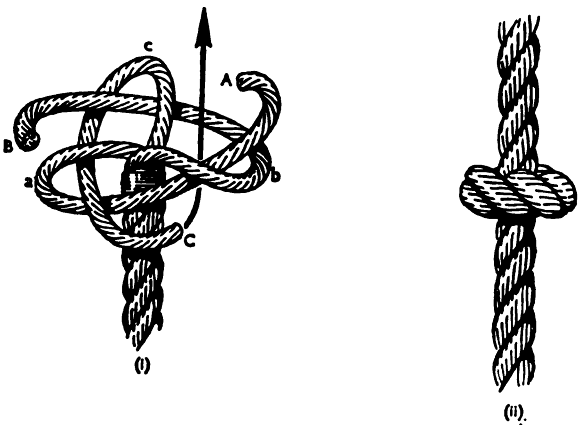


FIG. 4–16. Stopper knot or double wall

To make this knot, whip the rope at a distance from its end equal to at least four times the circumference of the rope, unlay the strands to the whipping, and form a wall knot (fig. 4–16(i)). Now pass A under B and C, and bring it up through *c* to the centre. Then pass B under C and A, and bring it up through *a* to the centre. Then pass C under A and B, and bring it up through *b* to the centre. Haul each strand taut at the top and in the centre of the knot, then whip all the strands together close to the knot and cut off the ends; or twist up the strands to form the original rope (fig. 4–16(ii)).

Six-parted crown and wall

This knot, although it appears more complicated, is made on exactly the same principle as a normal crown and wall. The six parts from a three-stranded rope are obtained by halving each strand, and relaying each part and whipping its end (fig. 4–17(i)). To make a six-parted crown, take A over B (fig. 4–17(ii)); take B round A, and then over C (fig. 4–17(iii)); take C round B, and then over D (fig. 4–17(iv)); then continue this with D, E and F; and, after taking F round E, pass F down through the bight *a* (fig. 4–17(iv)). Haul all the parts taut and make the six-parted wall underneath the crown as follows: take A under B (fig. 4-18(i)); take B round A, and pass it under C (fig. 4–18(ii)); take C

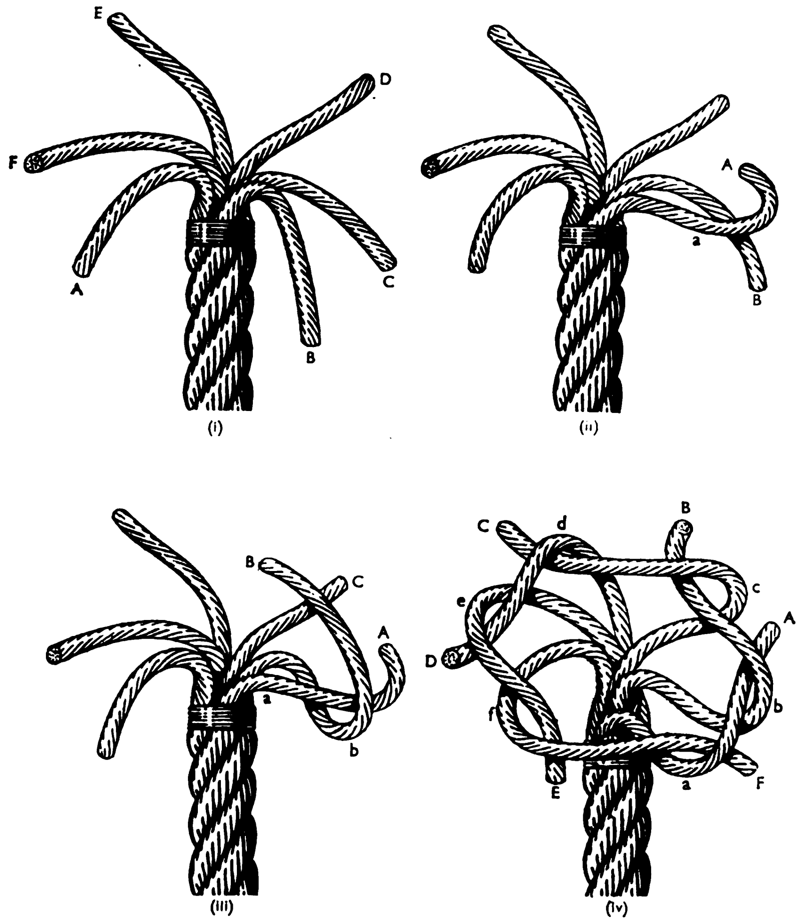


FIG. 4–17. Six-parted crown

round B, and pass it under D (fig. 4–18(iii)); then continue this to F; and, after taking F round E, pass F up through the bight *a* (fig. 4-18(iii)).

Single diamond knot

Both the single and double diamond knots are often made on the bight of a rope (such as a guest warp); the strands are then carefully unlaid, preserving their original lay, and laid up again when the knot is completed. To make a single diamond knot at the end of a rope, whip the rope at a distance from its end equal to four and a half times the circumference of the rope. Unlay to the whipping and hold the strands so as to form three loops placed equidistantly round the rope (fig. 4–19(i)). Then take A round outside B and up through *c;* take B round outside C and up through *a;* and take C round outside A and up through *b* (fig. 4–19(ii)). Haul taut all the strands and finish off by whipping the strands close to the knot and cutting off the ends, or laying up the strands in their original lay (fig. 4–19(iii)).

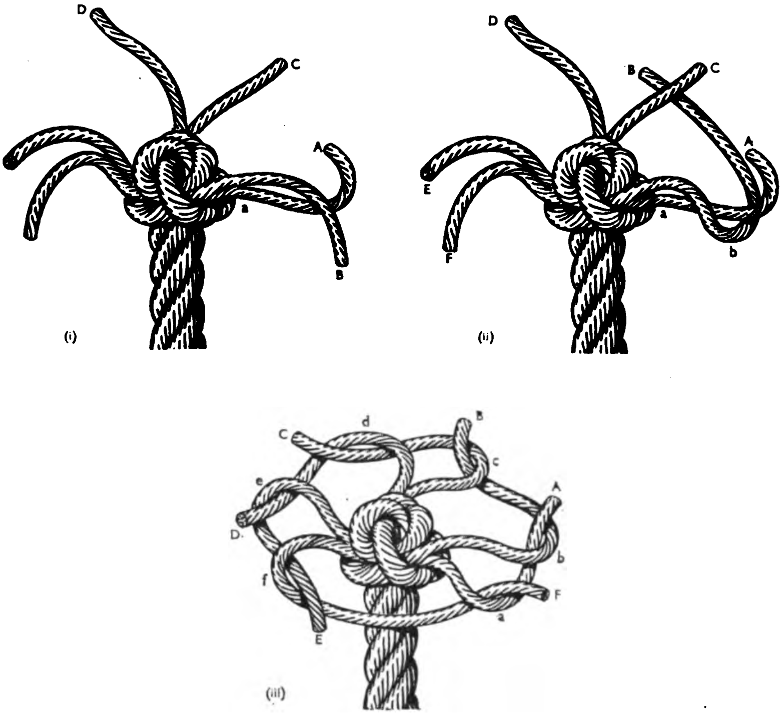


FIG. 4–18. Six-parted wall

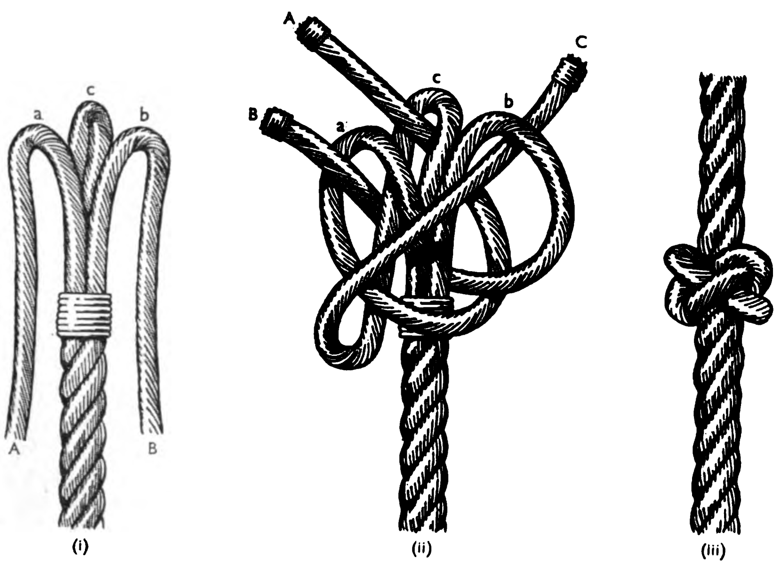


FIG. 4–19. Single diamond knot

Double diamond knot

Whip the rope at a distance from its end equal to six times the circumference of the rope. Then make a single diamond and with each strand follow the lead of the single knot, bringing the ends out on top of the knot. The strands are then hauled taut and finished off as for a single diamond knot (fig. 4-20).

FIG. 4-20. Double diamond knot

FIG. 4-21. Multi-parted double diamond knot

Multi-parted double diamond knot

There are numerous knots which can be made up from many strands, such as this knot. In fig. 4-21 it will be seen that two ropes can be joined together by knotting the six strands and then finishing off either by laying the strands up in their original lay, or by cutting off the ends a few inches from the top of the knot and unlaying the yarns so as to form a tassel. The six strands are placed together and stopped, and then a diamond knot is formed. Follow round each bight until the end of each strand is leading from the centre of the knot, then haul each part taut.

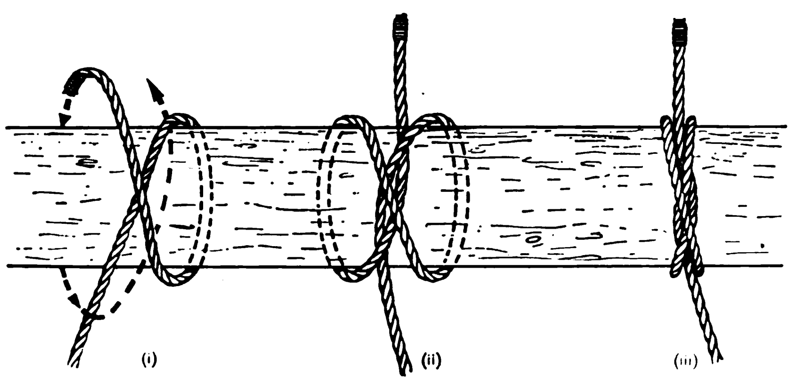


FIG. 4-22. Constrictor knot

Constrictor knot

This is a variation of the clove hitch, and is used when a firm grip is required, such as when holding a thimble in place prior to splicing a hawser eye. It is the most secure of all binding knots.

Take a round turn, follow the arrow in fig. 4–22(i) and haul taut.

GENERAL ADVANCED WORK IN CORDAGE

Nettle or fox

This consists of two yarns, or one yarn split in two, laid up together left-handed between the finger and thumb, as follows: The yarns are held between the finger and thumb of the left hand and pointing to the right; the nearer one is given a right-handed twist with the finger and thumb of the right hand, and laid left-handed across the other; the cross is held with the thumb of the left hand.

This is continued until the required length of nettle is completed, when an overhand knot is made to prevent its unlaying. The uses of the nettle are described below.

To point a rope

Whip the rope at a distance from its end equal to twice the circumference of the rope plus 6 to 8 inches, and unlay the strands to the whipping. Select a number of outside yarns from each strand and make them up into an even number of nettles, making each nettle from one yarn split into two. When completed, stop the nettles back along the standing part of the rope. Then unlay

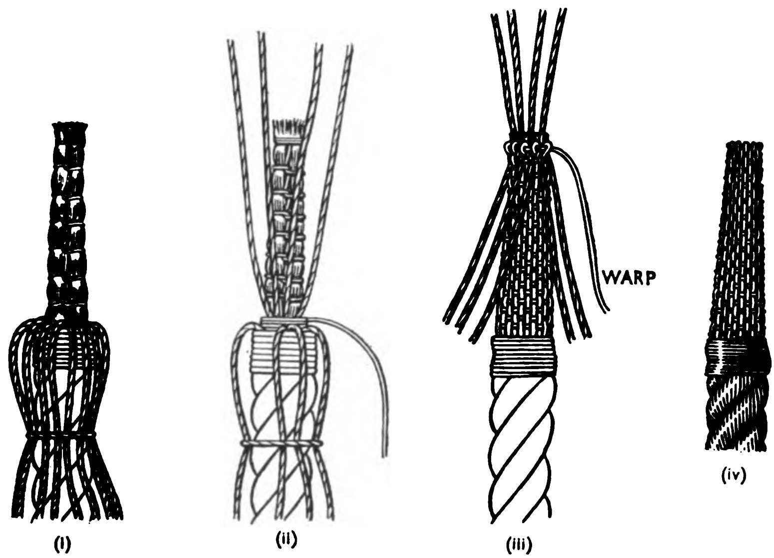


FIG. 4–23. Pointing a rope

the remaining strands and marl them down, cutting out a few centre yarns after each couple of turns of the marling so as to form a tapering heart on which to work the point (fig. 4-23(i)).

Unstop and divide the nettles, taking every other nettle down and back along the rope, and the remainder up and along the tapered heart; the former will now be called the 'lower' nettles and the latter the 'upper' nettles. Hitch a piece of twine (called the 'warp') with a couple of turns round the point where the nettles separate and as close as possible to the lower nettles, leaving the end of the warp free to pass again (fig. 4–23(ii)). Now bring the upper nettles down and the lower nettles up, and again pass the warp. Repeat this process until the pointing is of sufficient length (one and a half times the circumference of the rope), and then finish off as follows: Make a bight at the end of the point with each of the then lower nettles, so that the end of each bight lies back along the pointing, and pass the warp through these bights, binding the ends against the heart with a marling hitch (fig. 4–23(iii)); twist the top of each bight so as to form a figure of eight, and pass several hitches with the warp through these upper loops; then haul each loop taut with a small spike; then haul taut all ends and cut them off.

Cut off the upper nettles, the end of the warp, and the end of the heart protruding from the point (fig. 4–23(iv)). It will be found that a neater job will result if the nettles and the warp are well rubbed with beeswax.

Coverings

Grafting. This consists of nettles worked as in pointing, but it is used to cover the whole or any part of a rope instead of the end only. (Pointing, incidentally, can be regarded as a special kind of grafting.)

Grafting is often used to make an ornamental finish to an eye splice, as follows: Tuck the strands once; select sufficient inner yarns and with them worm the rope; then make up the remainder into nettles and proceed as in pointing. This grafting should extend for one and a half times the circumference of the rope.

Coachwhipping (fig. 4–24). This is used as an ornamental covering for boat-hooks, stanchions, bellropes, telescopes and similar fittings. It can be made up, with an even number of parts, from line, nettles, or alternate strips of blue jean and white duck, or any other suitable decorative material. The nettles are first secured by one end equidistantly round the fitting to be whipped (fig. 4–24(i)); in the following description of how this whipping is made the nettles have been numbered from 1 to 10.

There are different methods of making coachwhipping, and, according to the material used, it may be convenient to work either upwards or downwards or in any direction. In this particular example it has been decided to work upwards and to make the first cross to the right, but the instructions given below can easily be modified to apply to working the nettles downwards or otherwise. First, cross each odd-numbered nettle over the even-numbered nettle on its right, and hold or stop it up. Allow the even-numbered nettles to hang downwards (fig. 4–24(ii)). Cross each even nettle over the odd-numbered nettle on

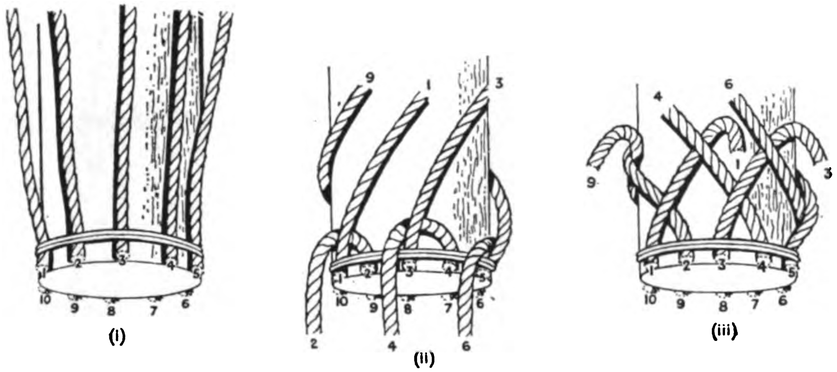


FIG. 4–24. Coachwhipping

its left. Hold or stop up the even-numbered nettles, and allow the odd-numbered nettles to fall downwards (fig. 4–24(iii)). Continue the first and second stages until the desired portion has been covered.

It will help if, on completion of each round, a stop of twine is passed round the upper nettles close to the cross. These stops are cut off when the work is finished. The extreme ends of the coachwhipping can be finished off tidily by covering them with a Turk's head.

Half-hitching (fig. 4–25). This is used extensively on the bow fenders of tugs. Splice an eye in a length of line and pass the end through this eye so as to form a ring round one end of the fender. Pass the end up through this ring and pull it down through its own bight, forming a half-hitch; repeat this operation to surround the ring with a complete row of such hitches, taking care to work round in the direction in which the crown of the spliced eye is pointing (fig. 4–25(i)). Then form a second row, making a half-hitch in each bight of the first

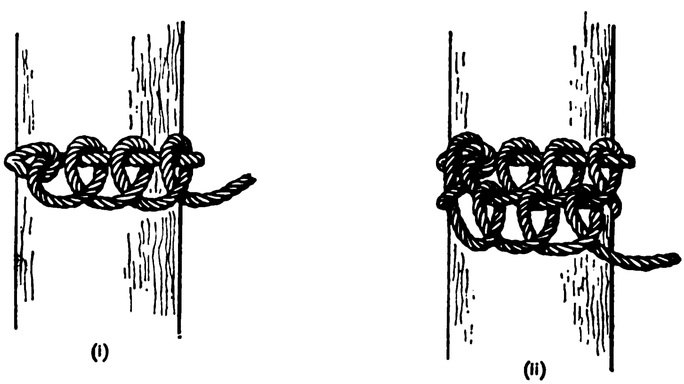


FIG. 4–25. Half-hitching

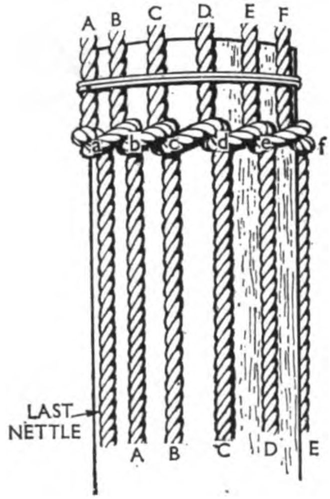


FIG. 4–26. Continuous walling

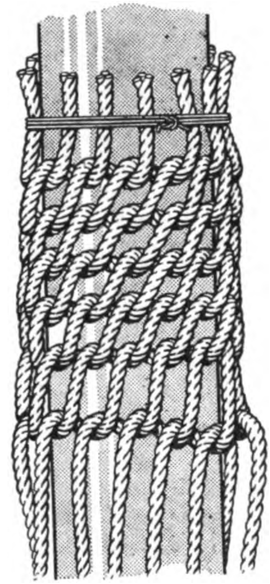


FIG. 4–27. Continuous crowning

(fig. 4–25(ii)), and then a third row and as many more as required. As the girth of the fender increases the number of hitches is increased by making two in one bight as often as necessary; as the girth decreases the number of hitches can be decreased by missing a bight periodically. It is finished off by passing the rope through each bight to form a clove hitch and then hauling taut.

Continuous walling (fig. 4–26). This is used as an alternative covering for a fender, or for decorating stanchions and other fittings. It uses less material than half-hitching. It is made from a number of nettles, or of lengths of suitable line or rope, each secured by one end to the fitting to be covered so that they are spaced round it equidistantly. The fitting—a fender, for example—is secured so that the nettles hang downwards, and it is then covered with a series of wall knots, each being made from the nettles as already described for a six-parted wall, i.e.: Pass A over B; then bring B up and over so as to enclose A, and place it over C; then bring C up and over so as to enclose B, and place it over D; then continue in this manner until the last nettle has been passed down through *a;* then haul the whole row taut and repeat the operation as often as necessary.

If the fitting to be covered is not of even diameter it is usual to begin continuous walling at the largest girth and then to decrease by discarding nettles as necessary. It can be finished off tidily by covering each end with a Turk's head.

Continuous crowning (fig. 4–27). This can be used to cover a rope, stanchion or similar fitting. It is made in the same manner as already described for a six-parted crown, and is prepared for working in the same way as that described for continuous walling. It may be found easier to work the crowns upwards, instead of downwards as in continuous walling.

Ringbolt hitching (fig. 4–28). This is used to cover curved fittings and is frequently used on circular fenders; it is made as follows: (1) Middle the length

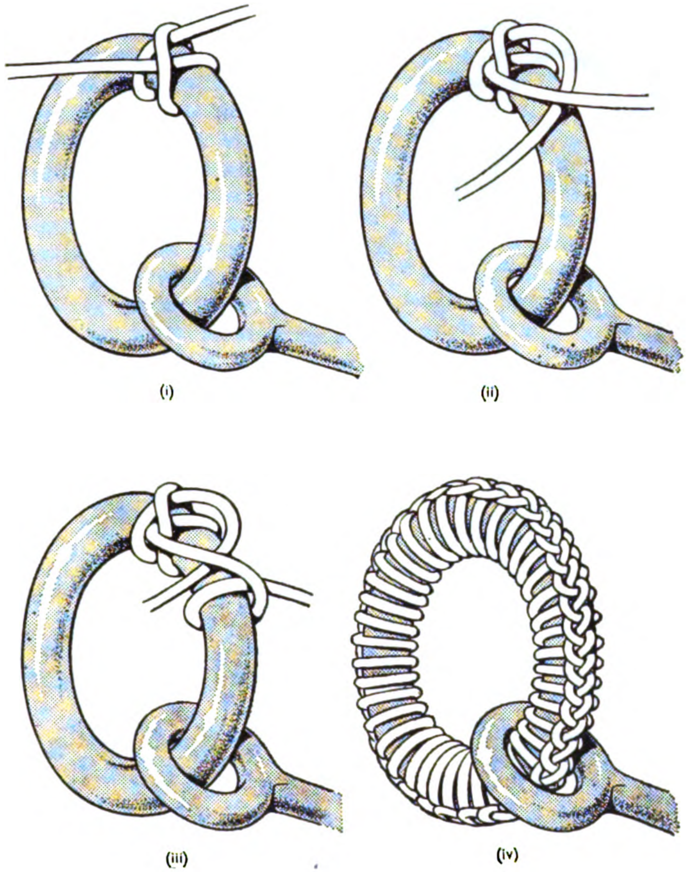


FIG. 4–28. Ringbolt hitching

of line and make a clove hitch round the eye (fig. 4–28(i)). (2) Cross the right part under the left and take it clear (fig. 4–28(ii)). (3) Make a half-hitch with the new right part (fig. 4–28(iii)). Repeat (2) and (3) as often as necessary to cover the eye, and finish off with an overhand knot so as to complete a reef knot.

Cockscombing (fig. 4–29). This is also used to cover an eye or a ring. It can be made using one, three or any odd number of parts. The description given below is for three parts.

Seize the ends of the three parts to the fitting, allowing two parts to hang on the right and one part on the left (fig. 4–29(i)). Take the part on the extreme right and make a half-hitch round the fitting, with the end coming out to the left and on top of the fitting. Next, take the original left-hand part and make a half-hitch to the right, with the end coming out to the right and on top of the fitting (fig. 4–29(ii)). Then take the part which has not been used and make a half-hitch round the fitting to the left, with the end coming out to the left and on top of the fitting (fig. 4–29(iii)). Continue this half-hitching with each part

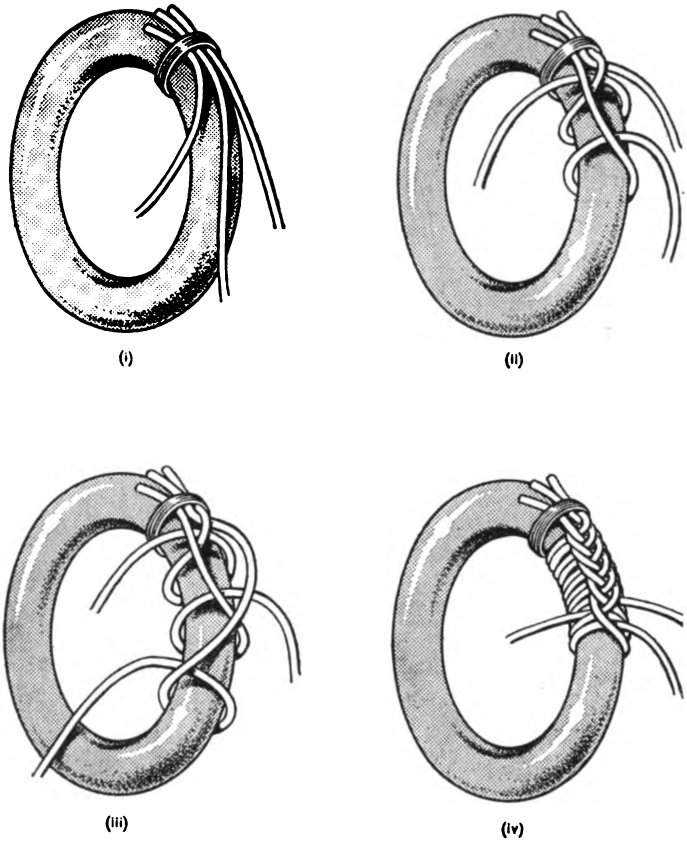


FIG. 4–29. Cockscombing

in succession, alternately to one side and to the other and always using the farthest back part, until the fitting is covered (fig. 4–29(iv)). Finish off each part with a crown and wall.

Cordage provision net

The nets most commonly used in the Royal Navy are the cordage and the wire rope provision nets for handling provisions and stores in bulk. The latter is described on page 119.

The cordage net (fig. 4–30) is made on a jackstay of 8 fathoms of 2½-inch sisal, and the mesh consists of about 120 fathoms of 1½-inch sisal. The mesh can be passed with the complete coil, but this is a cumbersome method, especially with sisal, because it necessitates taking out the turns which are put in the rope as the mesh is formed. For this reason it is simpler to pass the mesh with 30-fathom lengths, stretched and then coiled with a clove hitch around the middle, each length being long-spliced to the next.

To form the jackstay put it on a stretch, marry it at 44 feet, and join the ends with a short splice. Lay this out in a square with the splice near one corner, and

seize a round thimble into each corner with a round seizing of ⅛-inch sisal, using six turns over seven. Close in the square to sides of 8 feet in length and put temporary seizings at the four corners, making four beckets each 1½ feet in length. Now lash the beckets of one side of the jackstay to a spar at head level. Put a 30-fathom length of mesh on a stretch, coil it, and secure its first end to the top left-hand corner of the jackstay with an eye splice and stop it in place. Then take twenty turns of the mesh round the top side of the jackstay, working to the right, and space them evenly throughout its length (fig. 4–30(ii)). Secure each turn with a light stop, with the bight between each turn one hand's breadth in depth. The last turn is half-hitched and then half-hitched to the side of the jackstay, and the mesh is then worked back to the left in the following manner: The bight of the coil is passed up through the first bight of mesh and the coil is passed up through the bight so formed (fig. 4–30(iii)). The bight of the coil is then passed down through the same bight of mesh, and the coil is passed down through the bight thus formed (fig. 4–30(iv)). The parts are hauled taut and it will be found that a mesh has been formed with a reef knot at the cross (fig. 4–30(v)). The mesh thus formed should be 5 inches from corner to corner, and, after some practice, this can be judged by eye.

The mesh is continued to the left in the same way, and the first row is formed and finished, with a half-hitch round the first end and another half-hitch around the left side of the jackstay, before continuing with the second row of mesh to the right. The mesh is then continued, by working right and left between the sides of the jackstay, until twenty successive rows of mesh have been formed; each 30-fathom length of mesh is joined to the next with a long splice. The

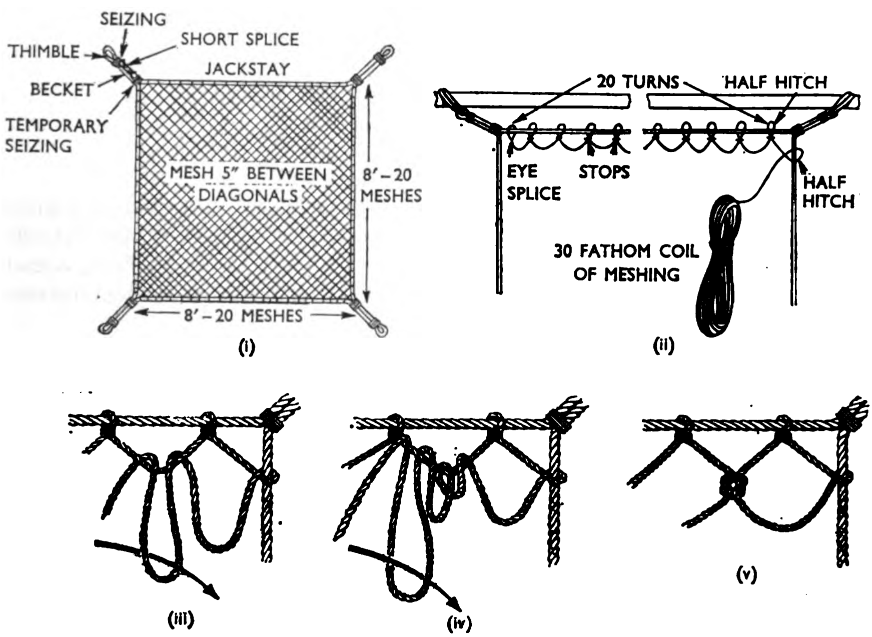


FIG. 4–30. Making a cordage provision net

last turns of the mesh are passed round the bottom side of the jackstay in the same way as the turns were passed round the top and sides, and the mesh is finished off at the bottom left-hand corner with a clove hitch and an eye splice.

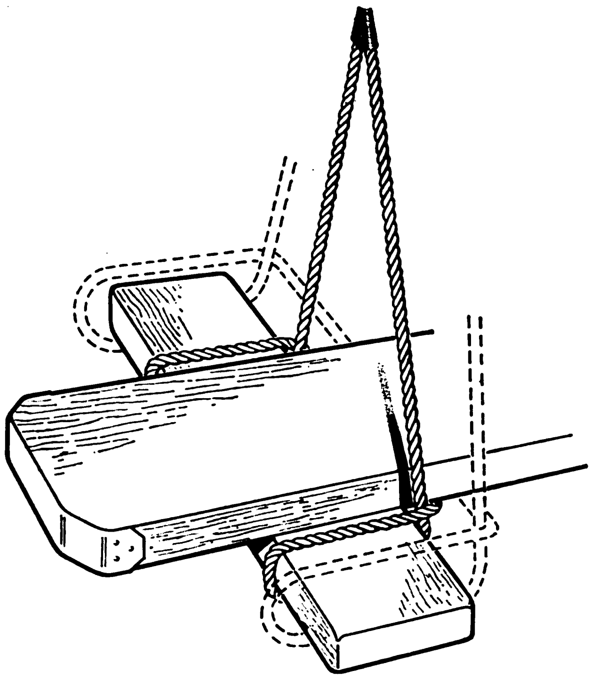


Fig. 4–31. Securing a lanyard to the end of a plank stage

Rigging a plank stage

Plank stages, suspended by rope lanyards at each end, are used to support men when working over the ship's side, or on superstructures and funnels. The lanyards are secured to a small crosspiece of wood, called a ***horn***, at each end of the stage; these project from the stage and so keep it a convenient distance from the fleet to be worked.

A long soft eye is either spliced or made with a bowline in one end of each lanyard and then placed under the end of the stage, with a half-hitch taken round each horn (fig. 4–31). The lanyard is then either passed round a cleat or similar fitting near the gunwale above, through the eye of a lizard rigged for the purpose, or, in larger ships, through blocks or chain gantlines secured to eyeplates or to the top of funnels; and the end is then brought down and belayed round the horns of the stage, thus enabling those working on the stage to lower themselves to the position required. *The lanyard should never be rove round a guardrail.*

When a lizard is used its tail is belayed round a secure fitting on the deck above the stage so that the eye hangs clear of all obstructions, giving a clear lead for the lanyard and avoiding chafe.

When chain gantlines are provided for rigging stages on a funnel they are unrigged when not in use, because they are noisy at sea and damage the paintwork. It should be possible to rig stages without having to let fires in the boilers die out, and, if other means of reeving the first gantline are not available it will be necessary to keep one permanently rove with a small wire rope. Once the first gantline has been rove the remainder present no difficulty, each being rigged from a bosun's chair sent up on its neighbour.

Rigging a bosun's chair (figs. 4–32 and 4–33)

It is the normal practice in the Royal Navy to tend a man from the deck when he is aloft in a bosun's chair. The gantline must be tended by an experienced seaman and be properly belayed to a secure fitting. However, on some occasions it may be necessary for the man himself to control his own positioning of the chair; and then the methods described below should be adopted. On no account should an inexperienced seaman be sent aloft untended.

A bosun's chair is a piece of wood about 18 inches long, 5 inches wide, and 1 inch thick, having two holes at each end through which two strops are rove and spliced underneath. A thimble is then seized into the bights of both strops and

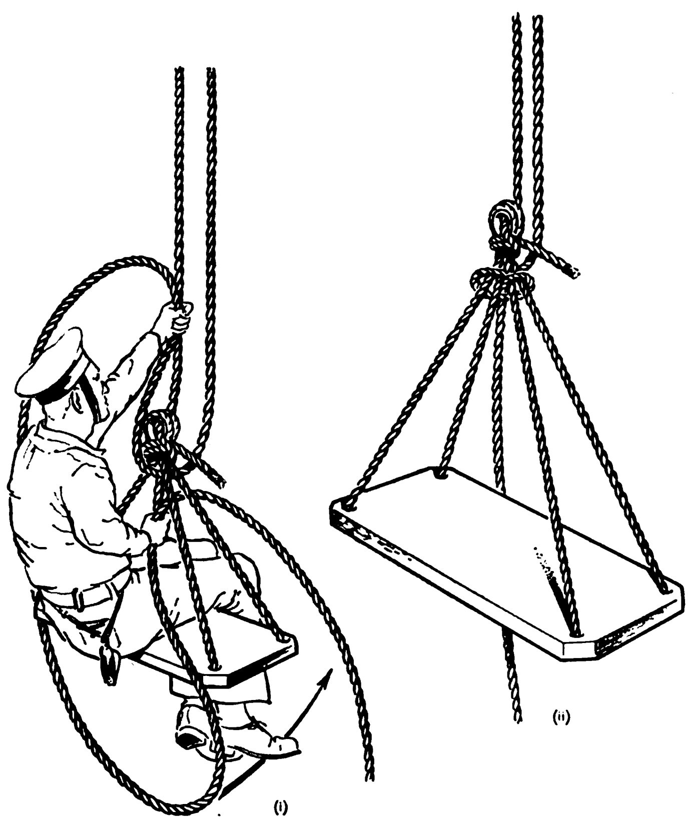


FIG. 4–32. Lowering hitch used with bosun's chair on a gantline

the gantline either shackled into the thimble or secured with a double sheet bend (fig. 4–32(i)). The first method of securing the gantline is as follows: The chair is hoisted to the required height and the man holds the standing and hauling parts of the gantline together, above the thimble; he then brings the bight of the hauling part through the sling of the chair and holds this bight to the standing part of the gantline: the other hand can now be released (fig. 4–32(i)). The bight is now lengthened by hauling more up, and when the bight is big enough it is passed under his feet and brought up to form a half-hitch (fig. 4–32(ii)). The gantline is then quite secure, and the chair can be lowered by hauling up some slack and rendering the turns, which is easily done.

The second method is illustrated in fig. 4–33. A large hook is secured just

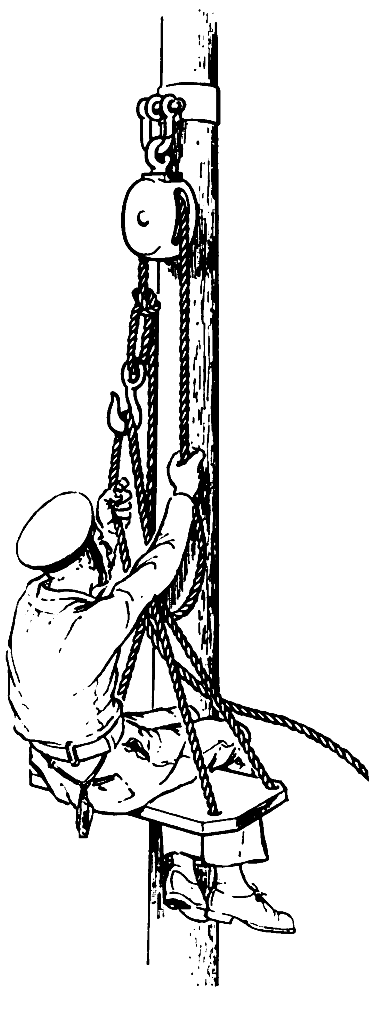


FIG. 4–33. Use of a hook for lowering bosun's chair on a gantline

above the sling of the chair to the standing part of the gantline. The bight of the hauling part is then brought up through the sling and placed over the hook, a second bight is brought up outside the sling and also placed over the hook, and a third bight can be passed if necessary. The stage can then be lowered as shown in fig. 4–33.

It may be necessary for a seaman to ride down the length of a stay, when surveying or blacking down the rigging, for example. The chair is slung from a large shackle placed on the stay, and the gantline is made fast either to the chair sling or to the shackle. It is important that the crown of the shackle and not the bolt should bear on the stay, otherwise the bolt may be revolved and come out as it rides down the stay. The chair can be manoeuvred past any obstruction on the stay by putting a second shackle on the stay below the obstruction and then transferring the weight of the chair and man to it, the original shackle then being removed and lowering continued.

Safety of men aloft

Whenever a man is working aloft on aerials and mast equipment and he requires to use both hands, a safety belt (Patt. 4132) must be worn and a haversack used for carrying tools.

When a man is aloft in a bosun's chair a lifeline should be passed round him and secured to the standing part of the gantline.

ADVANCED WORK IN WIRE ROPE

The construction and characteristics of wire rope, an introduction to wire splicing, and the making of an eye splice in wire have all been described in Volume I. This section is intended to advance the seaman to the more specialized work in wire, provided that he has become proficient with his tools and has made a good eye splice.

SPLICING WIRE ROPE

A well-made splice is not only dependent upon the skill with which the marline spike is used and the neatness with which the individual strands are tucked, but also upon the preparation of the wire before the actual tucking of the individual strands. The experienced seaman will invariably spend much longer in his preparation than in the tucking of strands; and so should you.

The modern advent of splicing by machine has created the impression that splicing is an art which belongs to the past, but at sea the seaman must be able to repair and replace rigging without the aid of a machine; for this reason alone the knowledge of hand splicing is important.

To break-in a rope round a thimble

A turning-in screw (fig. 4–34) is supplied to the Royal Navy in two sizes, for breaking-in a wire rope round a thimble. If one is not available the larger wire ropes can be broken-in in the manner described below and illustrated in fig. 4–35.

Find the position on the rope which will lie at the crown of the thimble and

seize the rope firmly into the crown at this point. Then secure the thimble and haul the rope into the form of a U, as close round the thimble as possible. Rig a Spanish windlass on the two parts of the rope below the neck of the thimble to haul them together. It will be necessary to put a light stop on the roller or

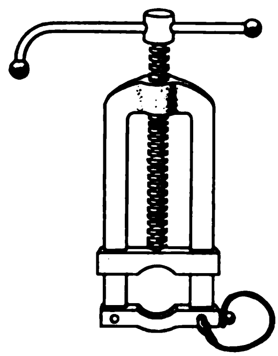


FIG. 4–34. A turning-in screw

bar of the Spanish windlass to counter the tendency of the windlass to slip down the rope as the parts come in. Bind the rope close in to the thimble at shoulder and throat with seizing stuff; each of these seizings should be secured on the inside of the thimble with a constrictor knot. Haul the seizings taut with a heaving mallet, then walk back on the Spanish windlass and take it clear. *Sweat up* first the shoulder seizings and then the throat seizings with a heaving mallet, as follows: after every heave take another turn with each part round thimble and rope; heave again, and repeat until the seizing is of sufficient size and the rope lying snug against the thimble at that point; then secure it and sweat up the next seizing. An occasional tap with a maul during the final stages will help to settle the rope into its place round the thimble.

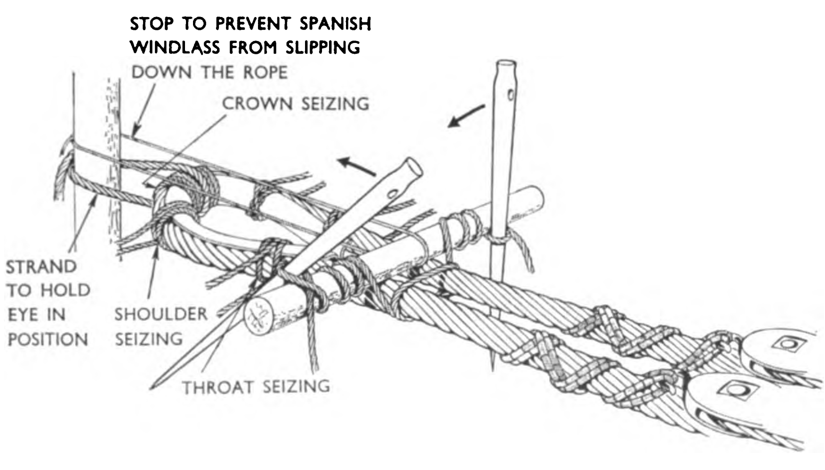


FIG. 4–35. Breaking-in a large wire rope round a thimble

An alternative to the Spanish windlass when using small and medium wire rope is to cross the parts and press the cross against a fixed metal bar or other fixture, as in fig. 4-36(i). Having closed in the parts as far as possible, pass a seizing round the cross. If the parts are now uncrossed and laid side by side, as in fig. 4-36(ii), the rope will be found to fit fairly snugly round the thimble. Finally, put on the two seizings and complete the join with a heaving mallet.

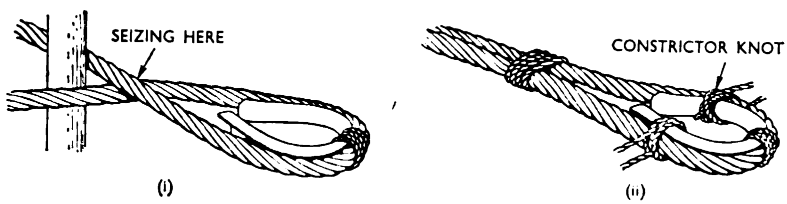


FIG. 4-36. Breaking-in a small wire rope round a thimble

When breaking-in small and medium-sized wire ropes it is not necessary to use the shoulder seizings, and an ordinary vice can be of great assistance.

To make a thimble eye

Whip the wire at a distance from the end equal to one foot for every inch of the circumference of the wire: for example, the whipping for a 3½-inch wire would begin 3 feet 6 inches from the end. The whipping should be put on with a serving mallet. The length should be equal to the circumference of the wire, and the material should be stronger than that used when placing a whipping for splicing cordage.

Measure with a piece of twine the outer perimeter of the thimble to be used, halve the twine, place it on the wire at the beginning of the whipping and leading away from the end of the wire, and make a chalk mark to denote the position where the crown of the thimble is to be seized to the wire. Now break-in the thimble, as described above, taking care to get the wire fitting snugly into the groove of the thimble; then whip the end of each strand, unlay the strands to the original whipping, and cut out the heart of the wire. Place three strands on one side of the wire and the remaining strands on the opposite side of the wire (fig. 4-37). Start to tuck the strands as for an eye splice. The first strand must be tucked under its proper strand in the standing part so as to

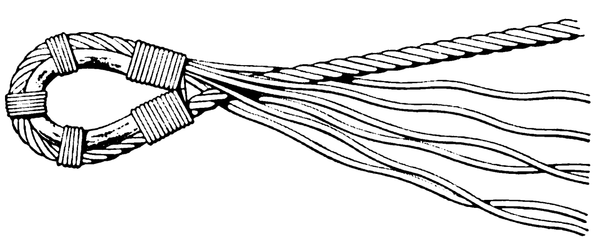


FIG. 4-37. Preparation for a thimble eye

give the eye a bowsing-in moment; otherwise, when the crown and throat seizings are removed after the completion of the tucking, it will be found that the thimble is loose within the eye. The splice is finished off as for an eye splice.

To make a hawser eye

A hawser eye (fig. 4–38) is found in each end of fitted hawsers supplied to ships, towing hawsers and towing pendants. It is a soft eye with a thimble seized into it after the eye splice has been completed. When the eye is parcelled

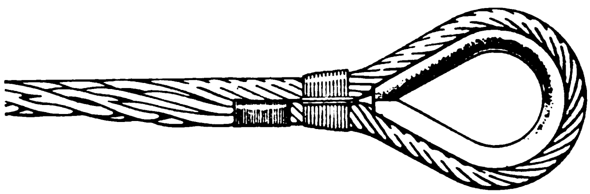


FIG. 4–38. A hawser eye

and served the thimble required for the larger diameter of the served wire is listed in the table below. Such servings cause corrosion of the wire and should not normally be carried out, in which case a thimble for a wire of half-an-inch smaller circumference should be used.

THIMBLES AND SEIZINGS FOR HAWSER EYES

Size of Wire Rope	*Pattern No. of Thimble*	*Size of Seizing Wire*	*Number of Turns*
in.		*in.*	
2½	5087	⅜	12
3	5088	⅜	12
3½	5089	⅜	14
4	5090	⅜	14
4½	5091	⅜	14
5	5092	½	18
5½	5093	½	18
6	5094	¾	18
6½	5095	¾	18

Having selected the correct thimble for the size of rope, whip the rope as for an eye splice, and from this whipping measure along the rope a distance equal to the circumference of the rope plus one and a half times the length of the groove in the thimble. This gives the position for the first tuck. Form the eye and then tuck and finish as for an eye splice. On completion the splice itself

should be parcelled and served, using three-yarn spunyarn for the service if the rope is 4-inch or less, and four-yarn spunyarn if more than 4-inch.

Finally, insert the thimble and seize it in place with a flat seizing, using the number of turns and size of seizing wire indicated in the table. It may be necessary to use a Spanish windlass for hauling the parts together.

To make a short splice

Put a stout whipping on each rope at a distance from its end equal to one foot for every inch of the circumference, securely whip the ends of the strands, unlay to the whippings, and cut out the hearts.

Marry the two ropes so that each strand of one lies between two of the other, hitch a line to the strands of each rope and haul the marry as taut as possible with a tackle or Spanish windlass, occasionally tapping the strands with a maul to assist them to settle in. When married, the distance between the two whippings for a short splice in wire rope should be a little more than half the size of the rope. Seize the strands on one side of the marry to the standing part on the other with a strong seizing; having hauled the first turns taut with a heaving mallet, it is advisable to put on the remainder with a serving mallet as for a serving. Cut the whipping on the opposite side of the marry and begin normal tucking. As with fibre rope, each strand is taken over the strand on its left and tucked under the next one, and it emerges between the latter and the subsequent one.

Having tucked each strand on that side of the marry once, place a seizing outside these tucks to prevent them easing back during the subsequent stages,

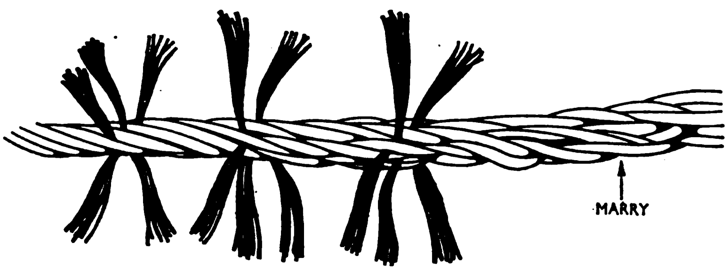


FIG. 4–39. A short splice

and then unlay each strand and cut out the core if of jute or hemp: if of wire, however, the cores are not removed. Then lay up the strands again. Tuck these relaid strands again, three times for rope of size 4 inches or less, and four times for rope of over 4 inches. Then take one-third out of each strand and stop it back. Tuck the remaining two-thirds once, and then stop back half of each. Tuck each of the one-third strands once and then tap down all tucks with a mallet, starting from the first tuck and finishing off at the tail, to remove any slack and to round-up the splice. Then break off all ends, including those stopped back, by bending each separate wire to and fro; though broken off short, a small hook is formed in the end of each wire which will prevent it from drawing.

Now remove the seizings and cut the whippings from the other side, and

tuck the strands on that side in the same manner. After rounding-up the whole splice, the tapered parts of it should be served so that all wire ends are covered. Fig. 4–39 does not show the servings.

To make a long splice

Whip each rope at a distance from its end equal to three feet for every inch of its circumference, unlay to the whippings and cut out the hearts. To assist in dealing with the long lengths of strands, some of which lengthen in the process of splicing, both ropes must be further prepared before marrying by whipping and cutting every other strand so as to reduce it to a convenient length of between 6 and 12 inches.

Marry the ropes so that each short strand has a long strand from the other rope on its right and a short one from the other rope on its left. As in the short splice, haul the marry very taut, seize the long strands on one side to the standing part, and cut the whipping on the other side. Unlay one short strand and follow it up with the long one from the opposite rope, which lay on its right in the marry, until reaching a distance from the marry equal to thirty times the circumference of the rope. This requires more knack than with fibre rope, and when once started it will help if each pair of ends is crossed so that each now has the other on its left instead of its right. Crossing a pair of strands also has the effect of locking them so that they will not unlay and will therefore remain in place when let go. Now take the second pair of strands, and then the third, and lay them up in the same manner, but lay up the second pair to a distance from the marry equal to eighteen times, and the third pair to six times, the circumference of the rope.

Remove the seizing from the rope on the other side of the marry, cross each pair of strands to lock them, cut the whipping, and repeat the above operation

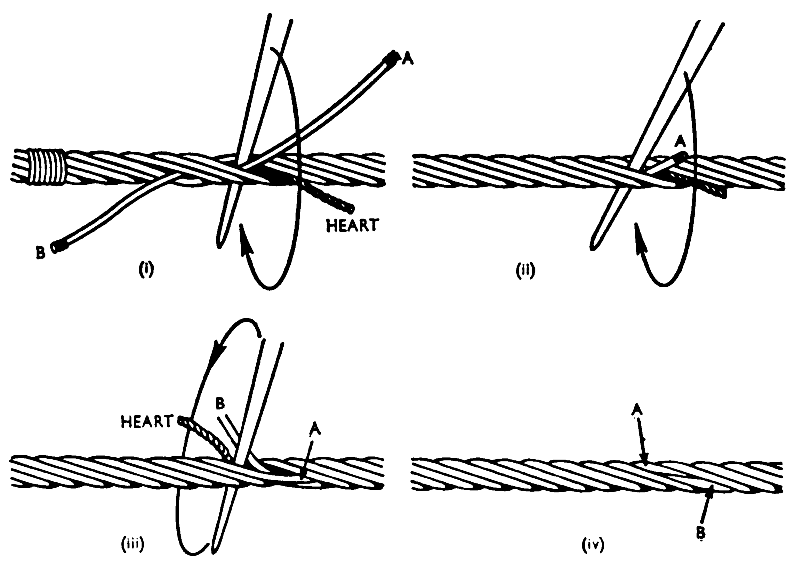


FIG. 4–40. Finishing a long splice

on the rope on that side. The result will be six pairs of strands equally spaced from each other at a distance equal to twelve times the circumference of the rope.

To finish off, the ends of the strands are buried inside the rope, the heart being cut out where each strand is buried and the buried strand taking its place; this finish requires skill. The following method is used for the six pairs of strands, working from the marry outwards: Take end A over its opposite number B and tuck it under three strands; the temporary whipping shown in fig. 4–40(i) will help to hold the ends in place when the tuck is made. Insert the spike under the next three strands, pull out the end of the heart, and bring round the strand just tucked so that it lies on the underside of the spike (fig. 4–40(i)). (As it is very difficult to insert a spike under more than two strands a second spike must be used when tucking under three strands, the first being withdrawn after inserting the second under all three strands.) Now work the spike along the rope with the lay, pulling out the heart, and it will be found that the end below the spike is forced into the centre of the rope in place of the heart (fig. 4-40(ii)). Repeat this operation with the end of the second strand, but instead of first taking it over one strand and under three, cut the whipping, insert the spike under three strands, and bury this end as already described (fig. 4-40(iii)). On completion the two strands will be lying side by side where they disappear into the centre of the rope, making a very neat finish (fig. 4–40(iv)).

Now treat the other five pairs of strands similarly, and, when completed, the buried ends should have replaced the heart for the whole length of the splice, a distance of seventy-two times the circumference of the rope. The lengths of the ends must be adjusted individually so that they should butt as near as possible.

To make a reduced eye

This eye is largely used for attaching the inner end of a wire rope whip to the drum of a motor bollard, and so it should be as flexible as possible. There are several methods of making it, but the following one is very neat and is flexible right up to the crown of the eye. The splice is stronger than the eye, and the eye is about 75 per cent of the strength of the rope.

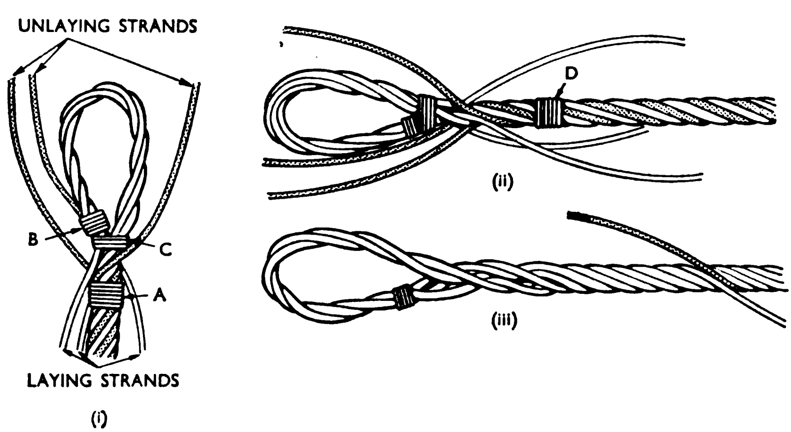


FIG. 4–41. Making a reduced eye

Place a strong whipping A at a distance from the end equal to forty-two times the circumference of the rope plus the intended circumference of the eye (fig. 4–41(i)). Unlay alternate strands to this whipping, having first whipped their ends; these strands will hereafter be referred to as the *unlaying strands*. Cut out the heart, leaving the remaining strands still laid up into a three-stranded rope. Place a second whipping B on this three-stranded rope at a distance from whipping A equal to the intended circumference of the eye. Unlay the strands (hereafter referred to as the *laying strands*) to this whipping, having first whipped their ends. Bend the three-parted rope to form the eye, so that each laying strand lies between two unlaying strands, and marry them up firmly. Put on a seizing C to hold the marry in place, and cut whipping A. Put on a third whipping D about 3 inches below the marry (fig. 4–41(ii)).

Tuck each laying strand under one strand of the three-parted rope and against the lay, as in fig. 4–41(ii), so that it emerges in a suitable position to follow up one of the unlaying strands, as in a long splice; then cross each pair of strands to lock them, and cut whipping D. The neatness of the finished job largely depends on the care with which the strands under which the laying strands are tucked have been selected; if carelessly selected the resulting splice will be long-jawed.

Finally, unlay and lay up the pairs of strands as in a long splice (fig. 44–1(iii)) to distances from the marry of thirty-six, twenty-four and twelve times the circumference of rope. Then finish as for a long splice, and remove whipping C.

To make a bale sling strop

Take a length of wire rope and join the two ends together with a short splice. Before marrying *take a half-turn out of the rope;* otherwise the strop will tend to form a figure-of-eight. Parcel and serve over the splice.

To make a bollard strop (fig. 4–42)

Work the rope as for a bale sling strop, marrying at 14 feet. Tuck each side four times, breaking down the strands after each tuck, as follows:

make the first tuck with the whole strands;
make the second tuck with whole strands, less their cores;
make the third tuck with two-third strands; and
make the fourth tuck with one-third strands.

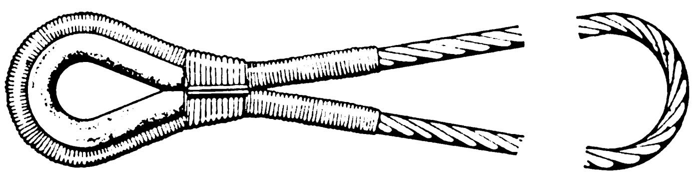


FIG. 4–42. Making a bollard strop

Serve the splice and then break it in symmetrically round a thimble, which must be seized in place with a round wire seizing. The thimble selected should, if possible, be some four sizes larger than the normal thimble for the rope used

to make the strop; a strop made from 3½-inch F.S.W.R., for example, would need a thimble designed for 5½-inch F.S.W.R.

Making wire grommet strops

The simplest form of grommet strop is known as a 'two-parted' strop and is made from a single strand formed into a ring and laid up round its own part until the ends meet again. If the ends are taken round a second time the result is a 'three-parted' strop, and so on until a 'six-parted' strop is achieved. In practise only three-, four- and six-parted strops are used.

To make any of the strops it is necessary to measure off accurately the length of wire required; otherwise wastage of wire will ensue. The formula for finding the length of strand required is the sum of twice the length of grommet required and twice the circumference of the wire used; multiply this sum by the number of strands in the strop, and finally add the tucking allowance for both ends. For example, a four-parted grommet strop with a length of 5 feet and made up of a strand from a 3-inch wire is required.

	ft.	*in.*
Twice the size of grommet required	10	0
Twice the size of wire		6
	10	6
Multiplied by four	42	0
Tucking allowance (1 foot for every inch of circumference)..	3	0
Total length of strand	45	0

Four-parted strop. Unlay the strand (after the wire has been measured off and cut) and mark it off from one end to a distance equal to the sum of twice the length of the grommet, twice the size of wire, and half the tucking allowance. Therefore in the example above the distance would be 12 feet. Now make a second mark at a distance from the first mark equal to the sum of twice the length of the grommet and twice the size of wire, i.e. 10 feet 6 inches. These two marks are married to give the correct length of the strop, and, for the purpose of this description, the ends are called the 'short' end and the 'long' end.

To make a strop, marry the strand at the marks so as to form a ring and lay up the short end with the lay (a strand from a right-handed rope should, of course, be laid up right-handed). Turn the strop round and lay the long end up to form a three-parted grommet. This can be done with the fingers, but care must be taken to keep the strand in its natural lay, particularly the second time round. Take care that whenever the strands meet they are crossed as in a long splice. At any stage of these operations the end which is not being laid up will have to be held in place, either by a stop or by hand, until the ends cross again.

Laying up the fourth part will require the use of a marline spike. Stop the short end and insert the spike under two parts of the strop, close to where the ends cross, so that the third part and the long end lie beneath it (fig. 4–43(i)). Work the spike along with the lay and the fourth part will fall into place correctly.

Both the three-parted and four-parted strops are finished off in the following manner: For wire up to and including 3-inch circumference each strand is

tucked over one and under two, the core is cut out, and the strand tucked again over one and under two. For wire above 3-inch circumference each strand is tucked over one and under one, the core is cut out, the strand tucked over one and under two, each strand is halved, and the remaining half-strand finally tucked over one and under two. The ends of the strands are then broken off and that portion of the strop served over.

Five-parted strop. If it is required to make a five-parted strop it is necessary to introduce a false heart into the strop after the four-parted strop is completed but not tucked (fig. 4–43(ii) and (iii) and (iv)). A high degree of skill is required both for this strop and for the six-parted strop described later.

As when laying up the fourth part, insert the spike under two parts of the

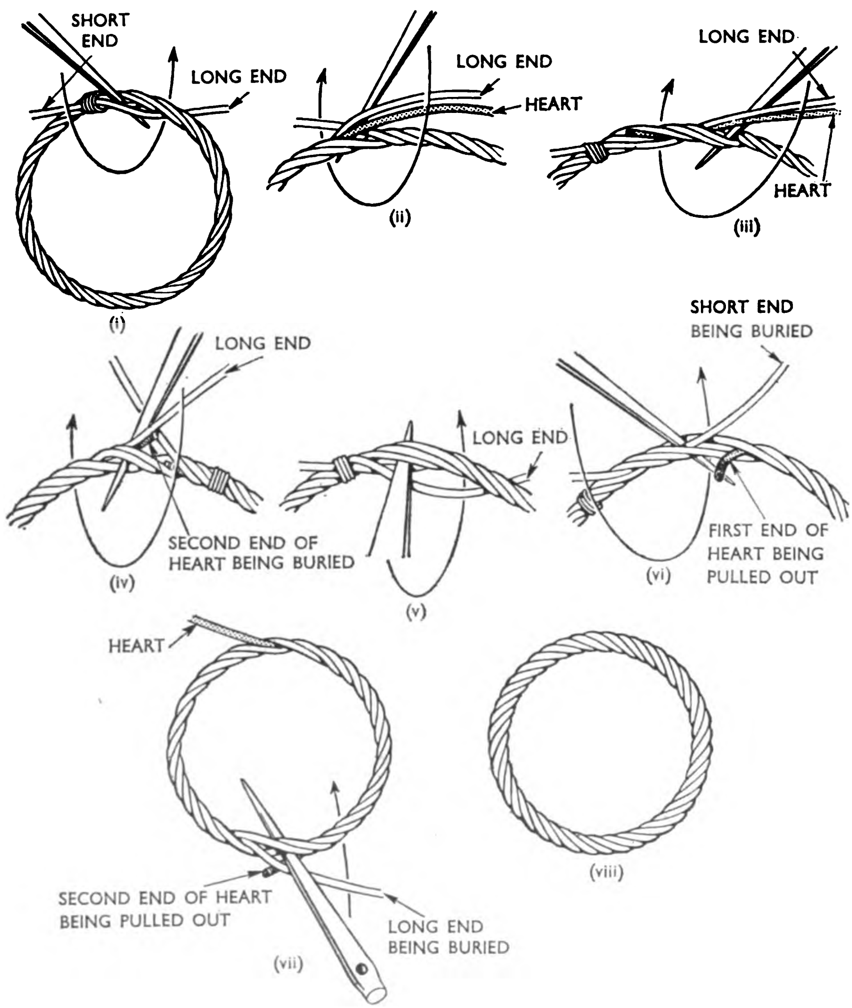


FIG. 4–43. Making a wire grommet strop

strop. Take another length of strand equal to the circumference of the ring and insert one end into the centre of the strop, beneath the spike, to form the heart. The long end of the strop is also placed beneath the spike, but must always be kept outside the heart or it will tend to take its place. The short end is held in place by a stop. Work the spike along with the lay, and, with care, the heart will disappear inside the strop and the long end take up its own place as the fifth part. Before its last end disappears it is most important that the length of the heart should be adjusted so that the ends almost butt. If correctly laid up a gap will show between two of the parts of the five-parted strop, and this gap is filled in the six-parted strop.

Six-parted strop. Proceed as for a five-parted strop; then fill the gap as follows. Stop the short end, then insert the spike under three parts, close to where the ends cross, and place the long end beneath it (fig. 4–43(v)). Work the spike along the lay, persuading the sixth part into place, and, at the same time, watch the heart carefully for any inclination to come out. It is a matter of choice whether to have the spike under or over the heart.

The strop is now finished as for a long splice, the heart being pulled out and replaced by the remaining ends of the original strand (fig. 4–43(vi) and (vii)). These ends must be of a length so that they almost butt.

Alternative method. There is an alternative method of making a grommet in which a pair of strands, instead of a single strand, is worked in the same manner, forming a four- or six-parted strop as required. This method has the advantages of being economical in material and making possible a somewhat longer strop, but more skill is required and it is not intended to describe it in detail.

Strength. The approximate breaking stress of grommet strops is given in Appendix I; a useful rule-of-thumb is that a doubled, four-parted grommet strop will be amply strong enough for joining two wire hawsers of a size half-an-inch larger than the rope from which the strop was made. For joining two 4½-inch wire hawsers, for example, a double, four-parted grommet strop made from a strand of 4-inch F.S.W.R. would be suitable. The connection can be made with a joining shackle.

To splice cordage into wire

This is necessary for dressing line whips and, where fitted, radio aerial halyards. Unlay the wire rope as for a short splice, keeping the strands in pairs, and remove the heart. Splice the wire and rope together as for three-stranded rope. Taper the strands as for a short splice, marl down and serve over.

Wire rope provision net (fig. 4–44)

The net is made on a jackstay of 9 fathoms of 1½-inch F.S.W.R., which is married at 46 feet and has its ends long-spliced together. The jackstay is closed to a square with sides 8 feet in length, and a becket 18 inches in length is formed at each corner. Each becket is seized at its throat and middle to form a soft eye about a foot long. Each seizing consists of eight turns of $\frac{1}{16}$-inch seizing wire.

The jackstay is pegged out on a frame, or on a flat surface, and pegs are driven in at intervals along the sides on which to form the mesh. The mesh is 6 inches square and made of 50 fathoms of 1-inch F.S.W.R. In spacing the pegs

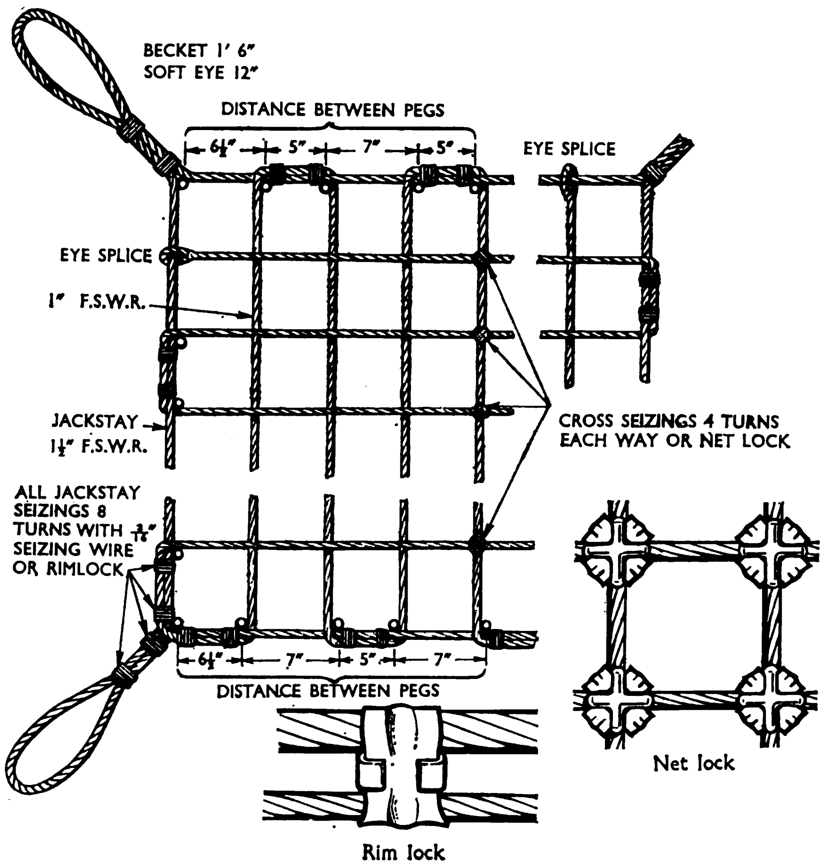


FIG. 4–44. Making a wire rope provision net

the diameter of the mesh rope must be taken into account; the pegs are therefore driven in, in pairs, at a distance apart of 5 inches and with a distance between of 7 inches, there being eighteen pegs (including the corner pegs) to a side.

The first end of the mesh is eye-spliced round the jackstay 6 inches from one corner, then taken to the opposite side, over the jackstay, round the first peg, and then round the second peg and under the jackstay. From there it is taken back to the opposite side, over the jackstay, round the first peg, and then round the second peg and under the jackstay. The mesh is seized to the jackstay at each peg with an eight-turn seizing of $\frac{1}{16}$-inch wire. This sequence is continued until all the rows in one direction have been completed. The mesh is then taken round the corner peg and round the first peg of the adjacent side, whence it is passed across to the opposite side, being tucked through the centre of each wire in the rows already passed. The meshes are seized where they cross with $\frac{1}{16}$-inch seizing wire crossed four times. The mesh is continued until the net is filled, and the last end is eye-spliced around the jackstay.

The task of seizing each mesh with seizing wire where it passes around the jackstay, and at each cross of the mesh, is long and time-wasting; therefore net

and rim locks are being introduced which, when clamped over the different positions, hold the wire to the jackstay, and each cross of the mesh, firmly in position. When the net lock is used the wire which completes the mesh is not tucked through the wire as described above, but is rove alternately over and under the rows already passed.

Wire seizings

Seizings with flexible mild steel wire are made in exactly the same manner as described in Volume I for cordage seizings, except that the methods of starting and finishing are different. Instead of passing the seizing stuff through a spliced eye a wire seizing is started by taking the end round one of the ropes to be fastened and then half-hitching it round its own part; and it is finished by breaking off the end of the wire as for a short splice in wire rope. A metal heaving mallet is used for wire seizings, and after each heave the mallet should be run up and down the part of the wire that has been round it, in order to *clean out* the turns.

Wire services

A wire service is started and applied in exactly the same manner as a spunyarn service, but with the larger sizes of flexible mild steel wire it may be necessary to stop the first end down to the rope until sufficient turns have been applied to hold it firmly.

Also, it is customary to finish the service of an eye splice in a similar manner to that of a seizing; a cross turn is therefore taken round the last few turns of the service, inside the neck of the eye, and is followed by a clove hitch, the ends of the wires being then broken off by twisting and carefully tucked away so that no harm will result when the rope is handled.

Talurit splicing

The average seaman will often see this splice on board, but will seldom be required to make it, or even have the opportunity to see how it is made. Nevertheless it is important for him to know the facts about this type of mechanical splice, its advantages over the hand splice, and a broad knowledge of how the splice is made.

Talurit splicing for the Royal Navy is carried out only in Royal Dockyards, on board Fleet Repair Ships and commercially under contract. In a great many cases it has superseded the hand splice—for splices in standing rigging, slings

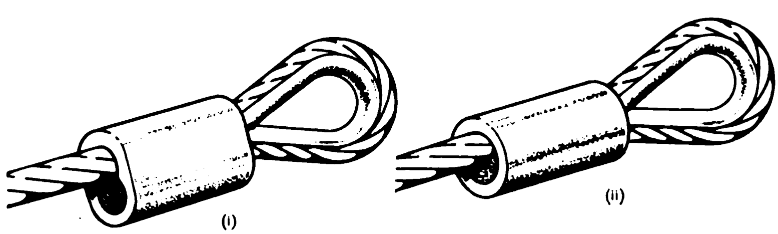


Fig. 4–45. Talurit splicing

and aircraft launching bridles, for example. Talurit splicing saves wire because, while a hand splice requires a tucking allowance of one foot of wire for every inch circumference, the Talurit splice requires only one inch. The splice requires no worming, parcelling and serving; it is completed in one-tenth of the time taken for hand splicing and does not reduce the strength of the wire.

To make a Talurit splice. One end of the rope is threaded through a non-corrosive alloy *ferrule* of suitable size and then threaded back on itself through the ferrule to form a loop (fig. 4–45(i)). Should a thimble or other type of fitting be required, it is placed in the loop in the necessary position. The ferrule is then put in the hydraulic press between two *swages*, which are of a size to deal with that particular ferrule, and the swages closed until they slightly grip the ferrule. The rope is then pulled through until the loop of the required size is fashioned or the tightest possible fit to the thimble or other fitting is obtained. Further pressure is then applied until the swages meet; the splice is then complete. The pressure exerted does not harm the rope in any way, neither is the lay disturbed—the metal of the ferrule *flows* round the rope strands, holding each strand firmly in position (fig. 4–45(ii)).

The modified Liverpool salvage splice

In Volume I and in this chapter the Admiralty Service splice has been described; and within the General Service this is the official method of splicing wire rope. Some sections of the Royal Navy—for example, Boom Defence and Salvage—have long recognised the need for a splice of comparable strength that can be quickly and easily made and one which would, by its formation and sequence of tucking, allow a reduction of the usual tucking allowance of one foot of wire for every inch of its circumference and thereby save wire.

Advantages. The strands of this splice are tucked with the lay of the wire, each strand being tucked the required number of times without removing the marline spike between tucks, and the cores remain in the strands. This allows the splice to be tucked in a tenth of the time of the Admiralty Service splice. The taper is introduced by varying the number of tucks of adjacent strands, a much quicker method than that used in the Service splice. The tucking allowance is one foot of wire for every inch of its circumference minus six inches; therefore the overall saving of wire when a large number of splices are required is considerable.

When the tension in a wire approaches its breaking strength the splice will begin to draw towards the neck of the splice, and so give ample warning that tension should be eased.

Disadvantage. When used on the end of a tail or whip which is free to turn the splice tends to unlay and draw.

To make a Modified Liverpool Salvage splice. The wire is prepared as for a Service splice, but with its reduced tucking allowance. The wire is then hung from a convenient fitting, with the unlaid strands pointing downwards, and a suitable weight is hitched to the standing part of the wire just clear of the deck (fig. 4–46(i)). When tucking each strand, its end is entered into the standing part of the wire above and in the opposite direction to the marline spike (fig. 4–46(ii)). The first strand is tucked through three strands and is then stopped up clear until it is finally tucked (fig. 4–46(iii)). The second strand is tucked

through the same hole, but only under two strands, and is then tucked another four times round the middle strand of the three under which the first strand was placed (making five tucks in all) without removing the spike (fig. 44–6(iv)). The third strand is tucked through the same hole, but only under one strand, and is then tucked another three times round that strand, in the same way as the second strand (fig. 4–46(v)). The fourth, fifth and sixth strands are now tucked five, four and five times respectively round their appropriate strands.

When the sixth strand has been tucked, return to the first strand and tuck it

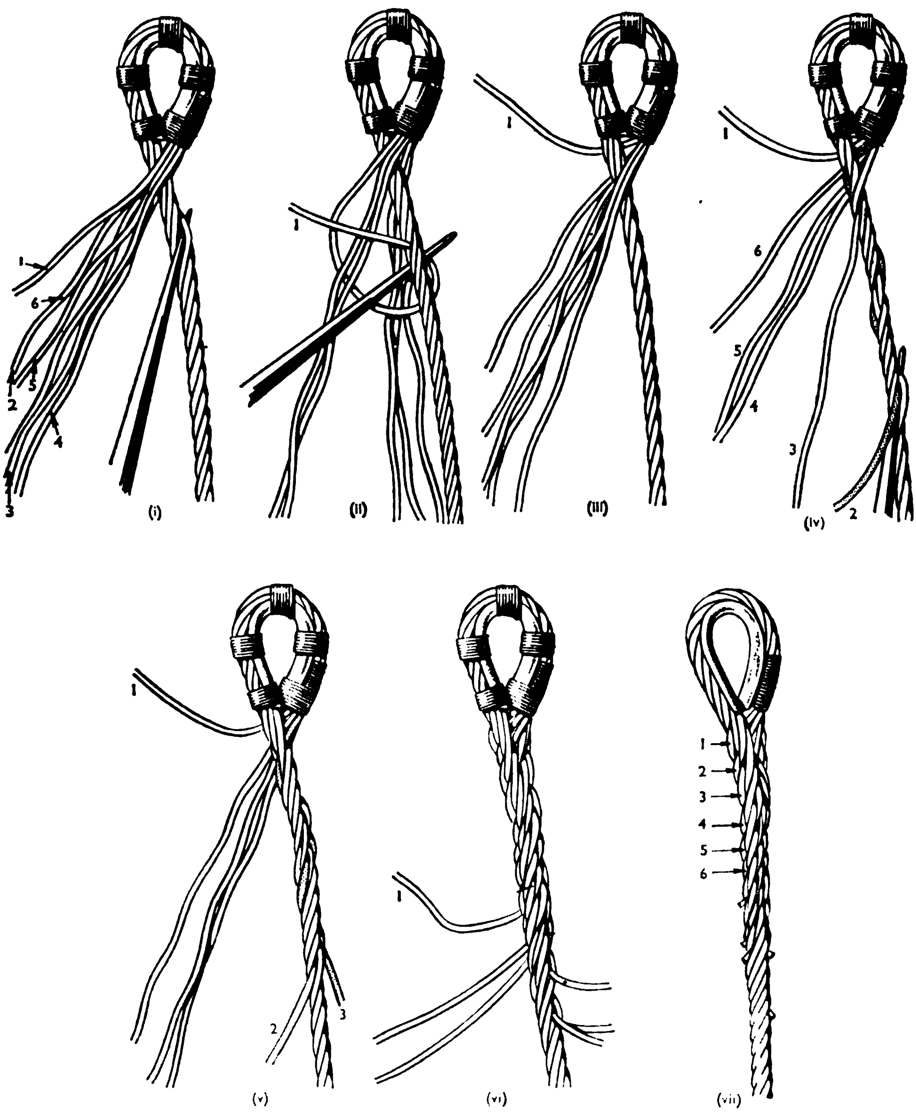


FIG. 4–46. Making a modified Liverpool salvage splice

another three times (fig. 4–46(vi)). The strands are tucked alternately four and five times in wires up to and including 3½ inches, and five and six times in wires over 3½ inches, thereby giving the splice a long, tapered appearance. This completes the splice, and the ends of the strands can now be either cut or broken off (fig. 4–46(vii)).

END TERMINALS ON WIRE ROPE

Besides the soft, thimble, and hawser eyes, other kinds of terminals are used for the ends of wire rope and some of them are described below.

Bordeaux connection

This connection (fig. 4–47(i)) is used for attaching wire rope to short link chain when both wire and chain are required to pass over a sheave, as in the whip of a crane used with a grab. The connection consists of a special pear-shaped thimble, deeply grooved to take the spliced eye of the rope; and a link, attached to it in a recess in its head, to take the end of the chain. The shackle connecting the link and the chain should always have its crown in contact with the link and the wire should be spliced round the thimble with a nine-tuck splice to provide a flexible and streamlined taper, and the diameter of the thimble should be equal to the width of the attached link.

Any sheave over which a Bordeaux connection is worked must be at least 50 per cent greater in diameter than that for the size of wire (see Appendix I), and the width of its groove must be greater than the diameter of the largest component.

These connections are subject to rapid wear under severe working conditions, and they should be examined frequently.

Sockets

Sockets of various kinds (fig. 4–47(ii)) are used extensively in commercial engineering; in ships they are used on aircraft arrester wires, shrouds, and certain other fittings.

When socketing a rope the wires at one end are fluffed out like a shaving brush to fill the hollow conical head of the fitting; the ends of the wires are then hooked over towards the centre, and molten white metal is poured in to make the whole head solid. This skilled work is normally done by dockyard and qualified Naval personnel. A well-made socket should have the strength of the rope, but the rope is subject to fatigue where it enters the socket because of the abrupt loss of flexibility. Frequent examination is essential, and if a single broken wire is seen near the socket the rope should be recapped without delay.

Shoe links

Commonly called *tulips* in the Royal Navy, shoe links (fig. 4–47(iii)) are seldom found elsewhere. Although strong enough for guardrails, they are much weaker than the wire rope. Tulips are usually fitted by dockyard personnel, who insert the whipped end of the guardrail into the tulip, make three holes in the rope coincident with those in the tulip with a small spike, and then rivet the rope in place with three copper nails driven through in alternate directions.

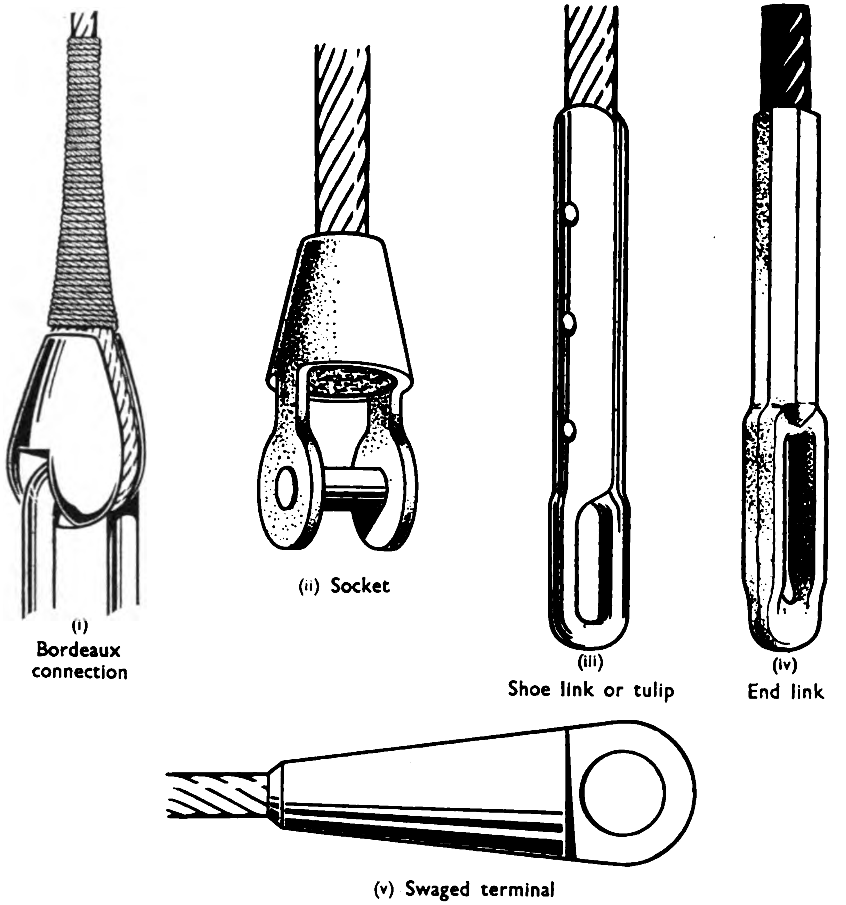


FIG. 4–47. Terminals for wire rope

End links

Most guardrails were formerly of F.S.W.R., the ends of which were fitted with the shoe link described above.

With the introduction of P.V.C.-covered aluminium alloy guardrail wire (described on page 127) it was found necessary to fit a watertight end link to prevent corrosion. The end link (fig. 4–47(iv)) is pressed on to the wire in a press similar to that used for Talurit splicing.

Swaged terminals

Swaged terminals (fig. 4–47(v)) are a modern alternative to the sockets described above and are used on some catapult wires. They can be made very compact to reeve easily through small apertures. The end of the wire rope is inserted in the terminal and both are placed in a special swaging machine in

which the terminal is hammered on to the wire. This process, which is carried out cold, does not affect the temper or strength of the wire.

SPECIAL TYPES OF WIRE ROPE

In addition to the wire rope whose construction has been explained in Volume I, other types of wire rope are supplied for sea service; the most common of these are described and illustrated below.

Lang's lay wire rope

A rope of Lang's lay (fig. 4–48) has its strands laid up in the same direction as that in which their constituent wires are twisted (i.e. both right- or left-handed).

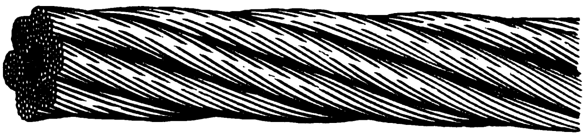


FIG. 4–48. Lang's lay wire rope

This makes a rope which is more flexible and wears very well when used for hoisting, but it can be used only when both ends are anchored (as in ammunition hoists, lifts, and crane topping lifts), because it is liable to unlay when under stress if one end is free to rotate. Care is needed in handling it owing to its tendency to unlay, and when unreeling it a bar should be lashed across the end to counteract any tendency of the rope to twist and unlay itself.

Preformed wire rope

During manufacture the individual wires and strands of this rope are given the exact helix they take up in the completed rope. In the manufacture of ordinary rope the wires are held forcibly in position throughout the life of the rope. This can be seen when the rope is cut and the strands and wires fly apart. When preformed the wires and strands lie naturally in their true position free from internal stress, and will not spring out of place should the rope break or be cut. However, when handling a bare end it is advisable to whip it lightly to prevent disturbance of the lay.

When used under similar conditions, preformed ropes have a longer working life and better resistance to kinking.

Non-rotating wire rope

The outer strands of this wire (fig. 4-49) may look like the Lang's lay formation, but all the wires and strands are very much smaller in size and the

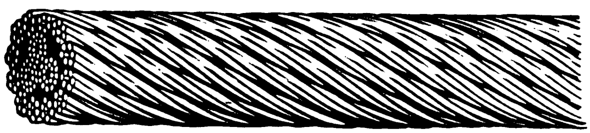


FIG. 4–49. Non-rotating wire rope

inner strands are arranged so that the tendency of the rope to rotate under load is reduced to a minimum. It is very flexible and is particularly suitable for crane whips, where strength and non-unlaying action are essential.

This wire requires very careful handling before and during installation if good service is to be obtained. It has no tendency to twist either way, but it is so pliable that turns either way can easily be imparted. When making fast the plain end to the side of the drum or crane structure ensure that the entire cross-section of the rope is firmly secured.

Serrated wire rope

This wire (fig. 4–50) is the standard type used for sweep ropes when mine-sweeping. It consists of four strands laid up round a hemp heart. Laid up in

FIG. 4–50. Serrated wire rope

each strand are two single wires twisted together. This feature forms, on the rope's surface, a series of serrated ridges which give the rope its chafing and cutting qualities. The lay of the wire can be either left-handed or right-handed. Further information on its use and the method of splicing is given in B. R.2215, *Minesweeping Manual, Vol. II.*

Aluminium alloy guardrail wire

The wire (fig. 4–51) consists of seven strands each of which contains seven wires. Six strands are laid up right-handed round the seventh strand and the whole wire is coated with a thick layer of P.V.C. The wire and the end link, described on page 125, are completely watertight and the assembly is tested to ¾ ton proof load.

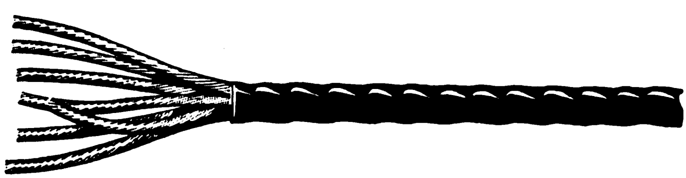


FIG. 4–51. Aluminium alloy guardrail wire

Combined wire and fibre rope

This is a rope of composite construction consisting of a mixture of fibre yarns and steel wires, resulting in a compromise between the strength of wire rope and the flexibility of cordage. Since the fibre is a structural part of the rope, damage to it will affect the strength of the rope. It is not supplied to the Royal Navy.

GENERAL REMARKS ON WIRE ROPE

The handling of wire ropes and hawsers, and the fitting, supply and maintenance of hawsers, are described in Volume I. This section describes how the seaman chooses the right wire for a particular job, the necessary precautions to take when working it, and how best to handle and take care of it.

Flexibility

Flexibility is introduced into a wire rope either by building the strands round a fibre heart and the wire in each strand round a fibre core, or by building the strands round a fibre heart and increasing the number of wires in each strand while reducing their individual thicknesses.

With flexible steel wire rope, which has a fibre heart and fibre cores to its strands, it would appear at first sight that the greater the number of wires in a strand the more flexible will be the rope. In fact, the flexibility depends upon the method of construction. A 6 × 12 F.S.W.R. is very flexible because it has only one layer of wires round the core of individual strands, and the size of the fibre heart and cores are relatively large in comparison with the size of the rope. In a 6 × 24 F.S.W.R., however, the wires in each strand are twisted in two layers round the fibre core, the size of which is relatively small, and the rope is therefore less flexible but stronger. Nevertheless, it can be said that in a rope in which the strands are built up of two or more layers of wires, the greater the number of wires in each strand the greater is the rope's flexibility.

In extra-special flexible steel wire rope the cores of the strands are of wire and there may be two, three, or even four layers of wires in each strand, depending upon its size and construction. This type of rope is considerably stronger than F.S.W.R., but it is not necessarily more flexible unless there is an exceptionally large number of wires in each strand. (In this respect it should be noted that the term 'extra-special' refers to the quality of steel of which the wires are made, rather than to the flexibility of the rope.)

A table in Appendix I (page 595) gives details of the construction, and compares the flexibilities, of different types of six-stranded wire rope.

Factor of safety

To determine the size of rope to be used for any working load, a factor of safety is laid down for different conditions of working, the following formula being employed:

$$\text{Safe working load} = \frac{\text{breaking strength of rope}}{\text{factor of safety}}$$

Having found the required breaking strength, the size of the rope can be ascertained from the tables in Appendix I.

The following factors of safety are used generally in the Royal Navy:

lifts and hoists	12
running rigging and slings ..	8
other purposes	6

More details of the various factors of safety are given in Appendix I.

The wear on a rope when working round a sheave depends more on the speed of action rather than on the weight lifted. In order to increase the rate of cargo-handling by crane or derrick it is therefore better to increase the weight of each hoist (if permissible) than to increase the speed of working.

When selecting the most suitable wire rope for a job, it is important to ascertain what is likely to cause the greatest deterioration. This may be one or more of the following agents: repeated bending, excessive wear and loss of area, crushing on a barrel which has two or more layers of rope, repeated shock loading or corrosion.

Sheaves for wire rope

Size of sheave required for a wire rope hoist. The table in Appendix I (page 595) shows the diameter of sheave required for each type of six-stranded wire rope supplied to the Royal Navy.

The diameter of a sheave used for any wire rope will considerably affect the life of that rope. As the rope bends round a sheave the strands and wires furthest from the centre of curvature move apart and those nearest the centre of curvature move closer together. This results in the generation of considerable friction between these wires and strands, and the smaller the sheave the greater will be the friction. Friction also increases rapidly with the speed at which the rope is moving. While the rope is bent round a sheave the outer wires are also subjected to a marked additional stress, and the smaller the diameter of the sheave the greater will be the stress.

For these reasons the *minimum* diameters of sheaves recommended from practical experience for various types of ropes moving at speeds not exceeding 200 ft/min are given in the table on page 595. For each increase in speed of 100 ft/min, 5 per cent must be added to these figures; this will give a rope a reasonable life, but it is emphasised that its life will be greatly increased if still larger sheaves are used. Similarly, if a smaller sheave than that recommended has to be accepted it will shorten the life of the rope, and on no account should a sheave be used that is more than 20 per cent smaller than the one given in the table.

Use of correct sheave. The life of a rope used for hoisting can also be considerably shortened by using the wrong *type* of sheave. The groove in the sheave must fit and support the rope as it travels round the sheave, otherwise there will be increased internal friction and external wear. Fig. 4–52(i) shows a sheave with too wide a groove, which results in a flattening of the rope and considerable distortion and internal friction. Fig. 4–52(ii) shows a sheave with too narrow a

(i) Groove too wide (ii) Groove too narrow

FIG. 4–52. Examples of incorrect sheaves for wire rope

groove, which results in the rope not being supported, the wires of the strands being subjected to considerable wear, and friction being set up between the rope and the sides of the groove.

The groove of the correct sheave should be shaped in cross-section to the true arc of a circle for a distance equal to one-third of the circumference of the rope, and the radius of the groove should be between 5 and 10 per cent greater than the specified radius of the rope (fig. 4–53).

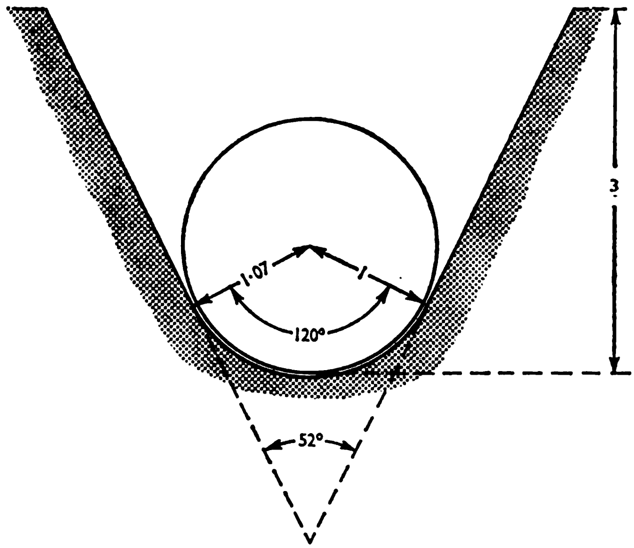


FIG. 4–53. Diagrammatic example of a correct sheave for wire rope

Blocks and sheaves. The sheave over which a rope passes must be examined periodically for:

1. freedom of movement, and to see that all parts are well lubricated and the oil-holes clear of paint and dirt;
2. wear and damage to the grooves, which will quickly ruin any wire rope (the diameter of the grooves must be checked by calipers, and the grooves examined for any *flats*);
3. buckling of side plates; many accidents have been caused by the rope jamming between the sheaves and side plates.

Maintenance

Life of wire rope. If not otherwise damaged, the useful life of a wire rope working round sheaves can be estimated from the number of times it will have to bend round a sheave. Also, a relation has been established by experiment between the size of the sheave, the factor of safety, and the resulting life of the rope. For example, a rope of construction 6 × 37 used on a sheave of diameter equal to six times the circumference of the rope, and loaded to one-eighth of its breaking strength (factor of safety 8) will have a useful life of about 65,000 bends; and if the diameter is increased to ten times the circumference of the

rope the life increases to 165,000 bends. Every part of a rope is bent each time it passes over a sheave, and a bend of 10 degrees causes nearly the same internal friction and extra stress as a bend of 100 degrees. All bends, however small, must therefore be taken into account.

When a rope passes over one sheave and then over a second sheave in a reverse direction (in the form of the letter S) it is subjected to a form of bending used to break off a single wire. This is known as *reverse bending* and is most detrimental to the life of the rope. Under the least adverse conditions it may halve the life of the rope; and under the worst, i.e. with the sheaves close together, a reasonable life for the rope cannot be expected.

Bad nips. When a rope is bent too sharply it is said to have a *bad nip*, and while in that condition a part of its strength is lost and it is very liable to be seriously crippled. The table below gives the percentage of strength remaining in a new flexible wire rope subjected to various degrees of bad nip.

Diameter of curvature	*Percentage of strength remaining*
0·5c	50
1·0c	75
1·5c	85
2·0c	90
2·5c	95
3·0c	97
3·5c	98
4·0c	99

c = circumference of rope

It will be seen that the strength temporarily lost depends upon the sharpness of the bend and not upon the deflection of the rope; the greater this deflection, however, the greater is the length of rope which will be crippled. In both figs. 4–54(i) and 4–54(ii), the loss of strength in the rope will be the same, but in fig. 4–54(ii) a greater length is subject to crippling.

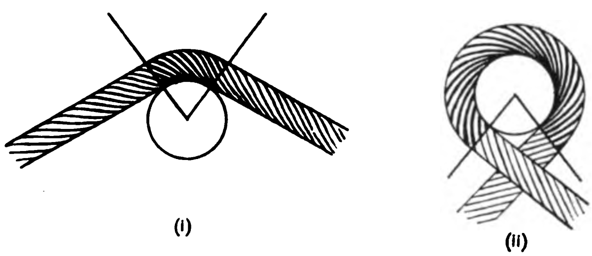


FIG. 4–54. Extent of crippling in a wire rope

Other effects of mishandling. When a wire rope remains belayed round a bollard for a long time it will tend to take up a set conforming to the shape of the bollard. This set does not, however, become pronounced unless the rope is subjected to stress, and the degree of set induced depends upon the load applied. Should this load be heavy the set will become permanent and the rope is then considered to be crippled; a pull of about half the breaking strength of the rope

may be expected to have this effect. Similarly, when a rope is surged under a heavy stress (equal, say, to about half the breaking strength), this permanent set will be induced throughout the part that has been in contact with the bollard. When released, the rope will take the shape of a coiled spring, the coils being the same size as the bollard round which the rope was surged. Though it certainly makes the rope harder to handle, the crippling just described does not materially reduce its strength unless accompanied by a flattening of the rope and consequent distortion of the strands.

A wire rope which is under a load approaching its breaking strength may emit a high-pitched whining note, which is caused by its elongation and the friction set up between its individual wires. If the rope parts, the ends may spring back on their own parts and flail; the more suddenly the load is applied the more liable are the ends to spring back when the rope parts.

A wire rope may show the effects of over-stress in elongation and in a reduction of its diameter. Such a rope should be treated with extreme caution.

Corrosion. Wire rope can be corroded by:

1. the action of damp on the wires from which the galvanizing has worn off; if this occurs to the inner wires first it causes rust to fall out of the rope and is therefore easily detected;
2. the action of fumes and funnel gases, which attack the outside wires, the effect then becoming visible on inspection;
3. contact with acid, which soaks into the heart and attacks the inside wires; this is not necessarily noticeable on the outside of the rope, and can be the cause of parting without warning.

Failure. Failure of a rope may be caused by damage, fatigue, worn or damaged sheaves, corrosion or lack of lubrication.

Except for the internal corrosion mentioned in the previous paragraph, and lack of lubrication, the first signs of the effects of these possible causes of failure can be expected to appear on the outside of the rope and thus give visible warning on inspection.

INSPECTION AND TESTING

Inspection

As every departure from the ideal conditions of working reduces the life of a rope, its frequent and regular inspection is necessary. Under normal conditions of use it is considered that a rope should be inspected every four months. If a broken wire is discovered on examination, then a wire rope or wire rope sling must be inspected on each occasion of use, or every month if not in continual use. When inspecting, the indications described below should be sought:

Distortion of strands. This is the result of damage by kinking, crushing, serious crippling round a bad nip, or other violent treatment; it is commonly found in berthing hawsers, picking-up ropes, and other ropes which have to be worked in adverse conditions.

Kinks need no further remarks, and other distortions are equally serious. If likely to cause the strands to bear unequal stresses they must be considered as reducing the strength of the rope by 30 per cent; and should they be sufficiently

serious to cause the heart to protrude, the portion of the rope affected must be discarded.

A crushed rope may be restored to some extent by the careful use of a mallet.

Flattening of some of the outer wires by abrasion. These *flats* are usually easily seen because the abrasion gives the flattened wires a bright and polished appearance, but they do not affect the strength of the rope unless they are very pronounced. Flats which extend to three-quarters of the diameter of the wires will reduce their cross-sections—and therefore their individual strengths—by 10 per cent, and as only a limited number of wires will be affected the loss in strength of the whole rope will be very small. (These flats must not be confused with flattening of the whole rope, which indicates distortion of the strands and is therefore much more serious.)

Broken wires. These are usually the result of fatigue and wear, and mostly occur in crane hoists. It is generally accepted that a wire rope has spent half its life when one wire of any strand breaks: the rope should then be examined more frequently, and, if used for hoisting, it should be discarded if more than 5 per cent of its wires are broken in a length equal to 3 times the circumference of the rope; for example, a 3-inch, 6 × 24, wire rope should be discarded if 7 broken wires are found in a length of 9 inches. This does not apply to socketing, where even a single broken wire may be serious. (A berthing hawser would, of course, become impossible to handle long before this number of breaks had occurred; this condition very seldom arises, however, because such ropes usually come to a violent end before fatigue has time to set in.) Should a suspiciously large proportion of the breaks appear in one strand, even though the total number broken in all strands is less than 5 per cent, the rope should be discarded.

Breaks due to damage will, of course, be of local significance only and not typical of any other part of the rope; if serious, only the affected portion of the rope need be discarded.

Corrosion. As already mentioned (page 132), most corrosion is easily seen, but any suspicion of contact with acid warrants the most careful examination.

Lack of lubrication is a frequent cause of corrosion. When a wire rope is under tension it stretches and becomes thinner, and during this process the individual wires are compressed and friction is set up; the fibre heart and cores are also compressed, releasing oil to overcome the friction. A wire rope of outwardly good appearance, but with a dry or powdery heart or core, should be treated with caution.

The method of lubricating wire rope is described in Volume I.

Effect of extreme cold. When subjected to extreme cold a rope may become brittle and lose its flexibility, and an apparently sound rope may part without warning. This effect is not permanent and the rope will regain its resilience in a normal temperature, but it should be remembered when working rope hoists.

Testing

Both before and after galvanizing, a sample is taken of each length of 1,500 fathoms or less, and by virtue of the continuity of its construction these samples

can be taken as typical of the entire length. From these samples a percentage of wires is tested individually, and a representative portion of the rope is tested to destruction, with the result that the performance of every new wire rope can be guaranteed. The strength of the finished rope depends upon the quality of the wires, and is calculated from the sum of their cross-sectional areas.

If the strength of a wire rope is suspect it can be subjected to its proof load which is generally two-fifths of its breaking strength.

CHAPTER 5

Deck Gear

'Deck gear' in this chapter includes items and fittings of rigging which the seaman is constantly required to handle during the normal day-to-day routine on board a man-of-war. The operation and maintenance of deck gear is basically the responsibility of the Seaman Branch, but other branches may be required to assist from time to time.

The rigging and fittings required for awnings and canvas work, laying out a hawser, towing, replenishment and moving weights will be found in later chapters.

RIGGING WARRANT

When one of H.M. ships first commissions she is issued with a *Rigging Warrant* by the yard at which she was fitted out. The Warrant gives details of all the items of standing and running rigging with which the ship is fitted and the materials of which each item is made, so that any item can be refitted or replaced by the ship's staff provided that the work is within their capabilities and the materials and fittings are available. The Warrant includes the rigging gear for masts, yards, gaffs, derricks, cranes, boats' davits, ammunition, torpedo and general-purpose davits, lifts, boat booms, anchor work, towing, awnings, ladders, fenders and stages, and miscellaneous gear such as berthing hawsers, tackles, gantlines, halyards, whips, slings, bollard strops, nets and guardrails. Details of fitted hawsers are not included, because they are Naval Store items, but the numbers and types supplied to a ship—also the numbers and types of awnings and other canvas gear—are included in the *Boatswain's List of Portable Fittings and Spare Gear*.

The officer borne for the duties of boatswain keeps the Rigging Warrant and records any alterations or additions made during the commission.

GUARDRAILS AND LINES

Guardrails

Guardrails were formerly made from F.S.W.R., but are now being replaced by black P.V.C.-coated aluminium alloy wire, which is lighter, more corrosion-resistant and more pleasing in appearance. Each wire is fitted at the ends with the special end link described on page 125, small enough to reeve through the hole in the guardrail stanchion. One end is shackled to a guard stanchion and the other is rove through the intervening stanchions and connected to the end stanchion by a screw and slip; the guardrail is then tautened by the screw. The end link is compressed on to the wire by means of special dies, and the completed guardrail is then tested to a proof load of ¾ ton.

Owing to the nature of their employment, certain ships will retain F.S.W.R.

guardrails for some time to come. The wires will be fitted with the thimble eyes and shoe links described on pages 111 and 124 respectively.

With the introduction of P.V.C.-coated guardrail wires the stanchions and their stays, and associated fittings, will be coated where possible with white plastic Nylon, which should *not* be painted or polished with abrasives. If it becomes stained by dirt, grease or oil, it should be wiped with a clean rag dipped in white spirit, or washed with a solution of soap and water.

It is obvious that greater care must be taken of coated wires and stanchions. A split in the coating, which leads to corrosion of the metal within, must be detected and repaired without delay.

Upper deck lifelines

In ships with a low freeboard, lifelines must be rigged for the protection of personnel at sea. These consist of short lengths of 2-inch sisal, with a manrope knot in one end and a round thimble in the other, threaded on a 2- or 2½-inch F.S.W.R. fore-and-aft jackstay. The jackstay is set up with a bottle screw and slip between suitable points of the ship's superstructure at a height of about 8 feet.

Bottom lines

These lines, rigged from one side of the ship to the other and passing under the keel, are used in diving operations to assist a diver to maintain his position under the hull. They are usually made from 1½-inch sisal, weighted to clear obstructions, specially made for various stations of the ship, and marked at the *centre of keel* and at the securing positions. The method of rigging depends on the class of ship, but they can usually be passed under the bow or stern, hung loosely and dragged into position, taking care to avoid any obstruction.

If a ship carries Clearance Divers, or ratings qualified as Free Swimmers, the diver or swimmer can take a messenger under the keel and the bottom line can then be hauled into place by means of the messenger.

Dressing lines

Masts and superstructures of H.M. ships have become so complicated since the advent of radar that it is seldom possible to hoist dressing lines in the centre line. Where suitable centre-line positions cannot be provided for dressing line blocks, they should be sited at the port or starboard yard-arms as high as possible. In two-masted ships the blocks should be sited so that the fore-to-main is, if possible, horizontal; if this is not possible the foremast block should be the higher. The positions of these and other blocks for ceremonial purposes are shown on the drawing of the ship's aerial and V.S. rig.

FENDERING

A ship going alongside another ship or jetty requires a resilient fender to absorb any initial impact, but the fender must be sufficiently unyielding to provide protection and sufficient separation to allow for any overhanging structure, proud propellers, etc.

For boats and other small craft whose sides are strong in comparison with the

weight of the vessel, fendering presents no difficulties and any soft fender is adequate. For larger vessels fendering must be sufficiently robust to withstand the crushing of the weight of the ship, and it must be large enough and sufficiently resilient to spread and absorb the shock over a large area of comparatively weak hull plating.

Fenders must be placed where the hull can best withstand impact; to some extent this applies to all ships, but in destroyers and frigates they must be placed at specified positions where the hull is strengthened by additional stiffeners near the waterline. Tally plates on the weather deck sometimes show the limits of the stiffening. Ships with light hulls, particularly modern frigates, are easily damaged by unyielding fendering, so specially resilient fendering has been developed for these ships and should be used whenever possible.

The fenders described below are divided into three categories, those that are portable (carried in ships), those that are mobile and provided in port (too heavy for ships) and those that are fixed to the structure of a jetty or pier.

Portable fenders

Rattan fenders (fig. 5–1(i)) are made of rattan cane and can be obtained in any reasonable dimensions. The sizes at present issued to ships are 4ft by 1¾ft and 2ft by 1ft. They are light, clean and suitable for coming alongside when resilient catamarans are not available.

Apple ring fenders (fig. 5–1(ii)) are made of lengths of junk cheesed down, one turn on top of another, to form a ring which is lashed round with ringbolt hitching. They are often used on the sides of tugs.

Pneumatic fenders (fig. 5–1(iii)) are ideal for light-hulled ships lying alongside a dock wall or other ships. They should be used when resilient catamarans (page 139) are not available. They must not be used when going alongside unless great care is taken and the ship is worked in normal to the jetty. Manufactured in two sizes, 7ft or 3½ft long and 2ft in diameter, they consist of an outer cover encasing an air-filled lining, both materials being similar to those used in motor car tyre manufacture.

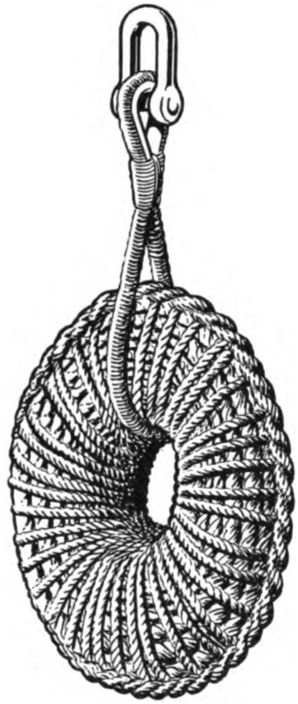
Destroyer fenders consist of long, light, channel-shaped lengths of wood hung horizontally by a lanyard at each end and used between destroyers and other wide-framed ships to spread shock over several frames. The fenders of two adjacent ships usually bear on each other, and rattan fenders are then sandwiched between them; this combination makes an efficient though not very robust fender. They are not suitable for light-hulled ships.

Brambleleaf. This fender consists of a spar served with rope and passed through a number of old motor tyres (motor scooter tyres in some cases). A wire lanyard is shackled to each end so that the fender can be slung horizontally. It is a satisfactorv and durable fender, but very heavy.

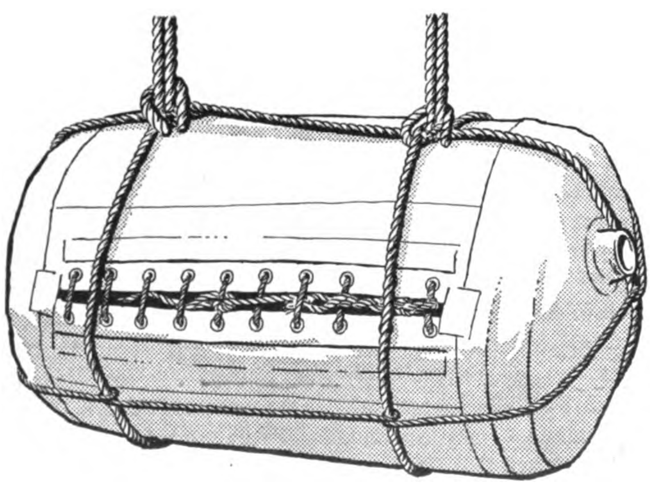
When destroyers, frigates and other light craft are fuelling alongside tankers in exposed anchorages and pneumatic fenders are not available, the securing lines are taken aboard the ship being fuelled, after securing alongside, to ensure that it will lie parallel to the more lightly constructed ship.

Light-hulled ships should use their pneumatic enders against the Brambleleaf fender.

(i) Rattan



(ii) Apple ring



(iii) Pneumatic

FIG. 5–1. Portable fenders

Roller fenders consist of a number of wood battens 2ft 8in. long, rove like a Jacob's ladder on three ½-inch wire ropes and spaced about 6 inches apart; the whole is then rolled round a 3-ft spar of 6-inch diameter whose ends are supported by wire lanyards. Suitable for protection against harbour craft.

Catamaran. Larger ships can use small wood catamarans for fendering harbour craft. The size depends on the lifting facilities and stowage space. To prevent the catamaran from tipping, the depth should not be less than one-third, nor more than one-half, of the width.

Port fenders

Catamaran. This is a stoutly constructed rectangular wooden or steel raft used in dockyards between ship and jetty, and also between ship and ship provided that the hull strength of both ships is sufficient. Unless a catamaran has sufficient depth it is liable to be turned on edge by the movement of the ship, particularly when it is light. A catamaran is not suitable for light-hulled ships unless the resilience is increased by fitting D-shaped rubber sections (12 inches wide and 10 inches deep) along each bearing face.

Compression catamaran. Designed for use with light-hulled ships, this catamaran consists of two rectangular tanks of a length not less than three ship-frame spaces, separated by resilient units fitted vertically on chains. The bearing faces and corners are fitted with elm or rubber rubbing pieces (fig. 5-2).

A *spar fender* consists of a baulk of timber, such as an old pile or the trunk of a tree, fitted with a swivel and lanyard at each end and used for fendering at a pier or jetty. Not suitable for light-hulled ships.

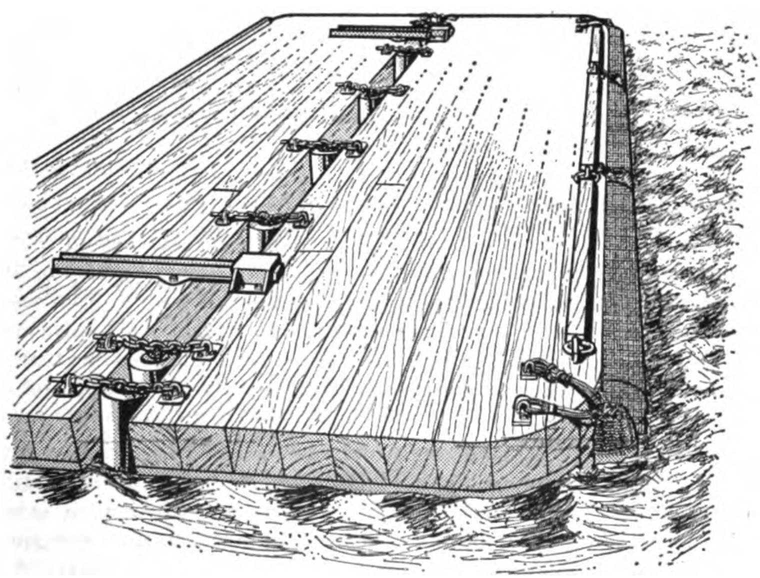


FIG. 5-2. Port fendering—compression catamaran

Fixed fendering

The solid walls of berths and the piles of jetties have vertical baulks of timber attached to protect the masonry or concrete and to provide fendering to ships alongside. In many commercial docks no other form of fendering is provided, but the use of suspended rubber units is increasing. In a tideway, to lessen the impact when a ship is brought alongside, some springing device is included between the timber and the masonry.

Advice on fendering

H.M. ships should normally be berthed on catamarans when alongside a jetty or other ship, the length of each catamaran being sufficient to span at least three frames. If the ship is of modern construction, compression or resilient catamarans should be used.

When catamarans are not available and limited space between a ship and dock wall or jetty can be accepted, rattan fenders should be used to take the initial shock of coming alongside, then pneumatic fenders should be used. A rattan fender can do more damage to a light-hulled ship than a catamaran fitted with resilient units, so greater skill in shiphandling is required. Once alongside, rattan fenders should be augmented by pneumatic fenders.

BOOMS

Booms must always be rigged so that they are horizontal and properly squared off, i.e. athwartships or fore-and-aft. This can easily be done by adjusting the topping lift rigging screw and slip or setting up on the guys.

The boatropes (see page 141) should always be clear of the water whether or not the billet is occupied by a boat; and it is good seamanship, when the weather is calm, to unrig boatropes during normal working hours. Conversely it is foolhardy not to have boats secured to their individual boatropes if the conditions of weather or stream merit their use, whether in working or non-working hours. It is also good seamanship in adverse conditions to shift boats from the lower boom to the stern or quarter boom boatropes if by doing so a lee is obtained; or to hoist them.

Standard boat booms

In cruisers and above, lower and quarter booms are attached to the ship's side by a gooseneck fitting and when not in use are swung forward or aft and the outboard end is housed within a clamp and secured by a drop-nose pin. In frigates and below lower booms are attached and stowed in a similar manner, but at upper deck level and inboard of the ship's side. This ensures that, when stowed, neither the boom, the gooseneck fitting nor the clamp is proud of the ship's side.

Booms are supported horizontally by a F.S.W.R. standing topping lift which can be adjusted by a rigging screw and slip fitted to its inboard end; and they are kept square by a standing guy and a working guy to which is secured a tackle for swinging the boom out into its correct position. Lifting eyes are fitted at each end of a boom so that it can be hoisted inboard whenever the ship has to make a long ocean passage, or if rough weather is likely to be encountered.

The boom is lashed down on deck or placed in its provided stowage.

Grommet strops, canvased to prevent chafe, are placed at intervals round booms to support the Jacob's ladders, lizards, and clump blocks for the boatropes. The tops of the booms are flat to afford a foothold, and from a convenient height a lifeline of F.S.W.R. is secured from the bight of the topping lift to a position either on the ship's side or above the upper deck, depending on whether the boom is fitted to the ship's side or at upper deck level.

The lower booms in frigates and below are fitted with eyes at the inboard and outboard ends to which is shackled a jackstay for running out the lifesaving net (see page 69). The net is connected to the jackstay by spring hooks and shackles. Where boat booms are fitted to the ship's side, non-slip foot rungs are welded to the side, between the heel fitting and the weather deck.

Quarter booms are smaller than lower booms and have two standing guys each fitted with a screw and slip. They are used for streaming the Admiral's barge, Captain's motor boat or other boats not riding comfortably at the lower booms. They are not usually fitted in smaller ships.

Stern booms are used for the same purposes as quarter booms and the fittings are generally the same. When the boom is secured to a wooden quarterdeck by two steel bands, guys are not fitted; when it is secured to a steel quarterdeck by a gooseneck fitting, two cordage guys are fitted. A cordage lifeline is only fitted when the topping lift cannot be used for this purpose.

Boatropes of comparatively heavy cordage are secured inboard well before the boom to give them plenty of scope and are rove through clump blocks shackled to grommet strops on the boom. The outboard end of each is fitted with a thimble eye and a short grommet strop, to which the boat secures. When unoccupied the end hangs a few feet above the water, being held in this position by a wooden toggle fitted in the boatrope abaft the clump block. In bad weather a boatrope should be eased out to give it a good catenary before the boom; the weight of rope absorbs any tendency of the boat to jerk as it rises and falls.

The boatrope of a seaboat has been described in Volume I, and the gangway boatrope is described on page 143.

Sounding booms

These booms are fitted only in ships of the Surveying Service and are used, in conjunction with an electric winch, for sea-bottom sampling and bathythermograph readings, details of which are given in the *Admiralty Manual of Hydrographic Surveying*.

LADDERS

The standard accommodation ladder

This consists of an upper and lower platform joined by a ladder (fig. 5–3). The sides of the ladder into which the steps fit are called *stringers*. The upper platform is hinged to the ship's side at its inner edge, and its outer edge is supported by two steel legs, the feet of which take into lugs fitted in the ship's side. The ladder is hinged to the after edge of the upper platform, and its after end is lowered by a tackle rigged from a special davit. The lower platform is

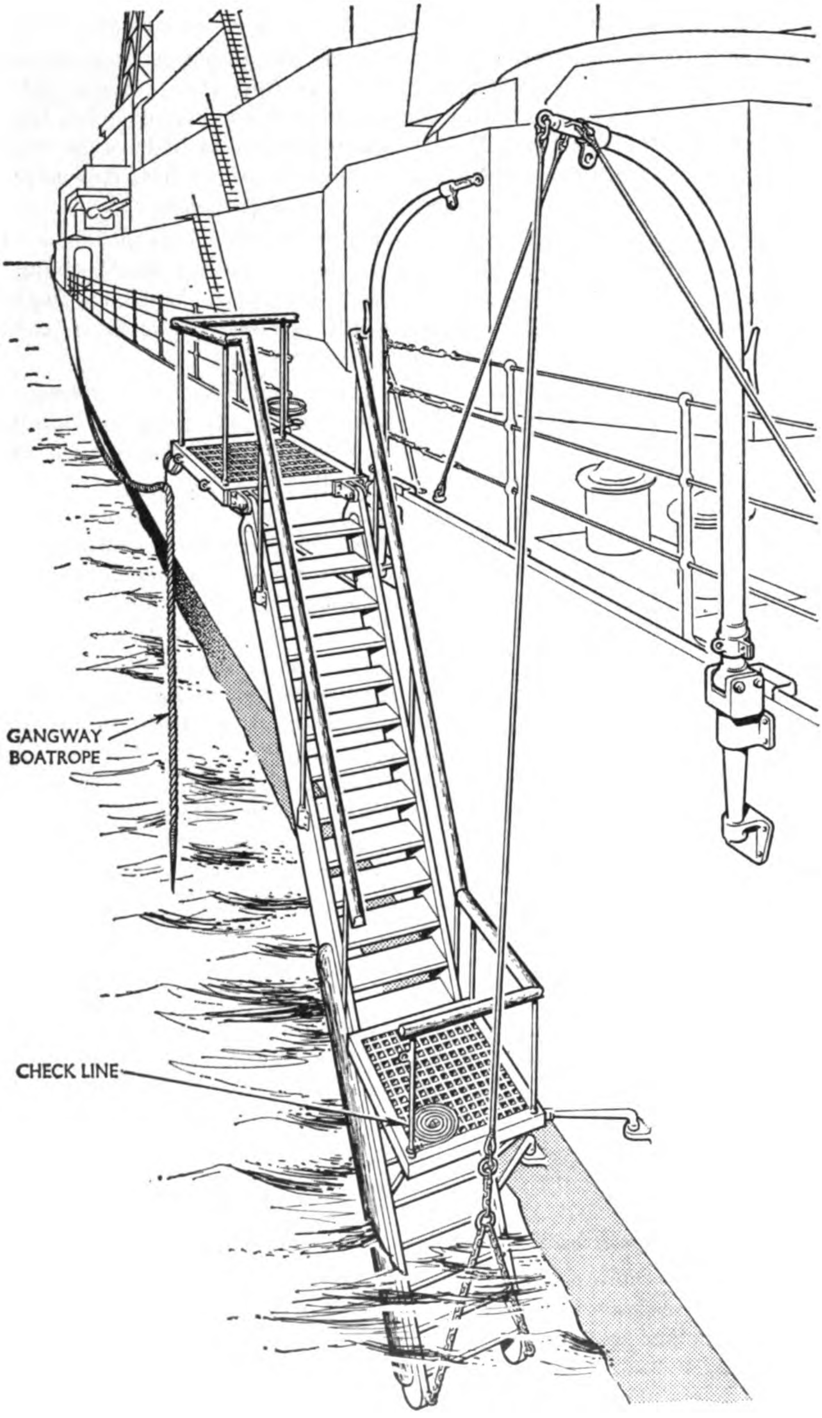


FIG. 5-3. Standard accommodation ladder

fixed to the bottom of the ladder, and when lowered in position the weight of this platform and the ladder are taken by a fitted pendant, the tackle being then removed. All the hinges have removable pins, so that the whole can easily be unshipped and dismantled.

The lower platform is also steadied by three legs which fit into lugs welded to the ship's side. Two sets of lugs are provided for the lower platform so that it may be at a convenient height above the water when the ship is at both deep and light load draught, and two pendants are provided for the same reason. The draught of a cargo-carrying merchant ship varies so much that the position of the lower platform of an accommodation ladder is adjusted by tackle, and the steps are mechanically adjusted to a horizontal position by a lever and rod system.

In small ships, manropes are rove through the tops of ladder stanchions, but in the larger ships wooden handrails are fitted instead of manropes.

In ships with a very large freeboard the accommodation ladder can be made in two halves: the upper half is similar to that already described, and the lower half consists of a second ladder leading from the intermediate platform to the lower platform. This intermediate platform is similar to the one at deck level, and the upper ladder is joined to both by hinges with portable pins. Such an arrangement is called a *two-throw* ladder.

Gangway and ladder gear

Gangway boatrope. This boatrope can be of the greatest assistance to a boat coming alongside in a rough sea or a tideway, but it is useless unless led well forward so that it lies nearly in the fore-and-aft line of the boat when she is alongside.

A length of smaller rope, known as a *stray line*, is spliced into the boatrope near the after end and belayed to a cleat abreast the upper platform. It is used for tricing up the boatrope when not in use, the end of the boatrope being then cheesed down on the platform. It is the duty of the gangway staff to lower the boatrope to each boat as she comes alongside, so that her bowman can belay it in the boat; the weight of the boat must be taken by the boatrope and not by the stray line.

When a ship is secured head and stern to buoys in a tideway, a second boat-rope should be rigged abaft the ladder for the use of boats coming alongside bow to stern.

Check line. This is a short length of cordage spliced round one of the out-board stanchions of the lower platform of the accommodation ladder, and is used by boats for checking their way and for keeping the stern in the proper position relative to the ladder. When a boat approaches, a member of the gangway staff should normally be at the bottom of the ladder to pass the check line to her: the line requires careful watching, because, if washed off the platform, it may foul the propeller of the boat. When not in use the line is cheesed down.

Safety measures

When lying in a strong current or tidal stream it is necessary to prevent a boat which overshoots the gangway from being jammed by the current under the ladder, and if ships' boats only are concerned this can be done by rigging a

simple *tide spar*. This spar is laid forward from the outer stringer of the ladder to the ship's side and lashed in position, but it must not project outboard of the stringer. If the ship is moored head and stern so that she cannot swing with the tide, a similar spar must be rigged abaft the ladder to protect boats coming alongside bow to stern when the ship is stern on to the tidal stream.

When heavy harbour craft are employed as tenders, a ship lying in the stream usually secures *catamarans*, some 12 or 15 feet long, on either side of her accommodation ladder.

An accommodation ladder should not be used when there is a sea or swell high enough to render boats liable to be caught underneath the lower platform; a jumping ladder should then be used instead.

Mediterranean ladder

This ladder is usually provided in smaller ships for use on occasions when the accommodation ladder is not rigged. It lies against the ship's side and is secured inboard by shackles and chain. The side stringers are of aluminium alloy channel bars reinforced at the lower ends with Canadian elm. The treads are of Canadian elm. Pads of English elm are fitted at the top and bottom to prevent chafing of the ship's side. The ladder can be made more rigid by rigging a forward and after guy to the lower end; it is then very serviceable under most weather conditions.

Stanchions are fitted, through which 3-inch manila manropes are rove. These manropes are fitted with a Turk's head at the upper end, pointed and tailed at the lower end, and then secured to eyes at the bottom of the stringers as described in Vol. I, page 172 ('Rigging lanyards').

Side or chain sea ladder (jumping ladder)

This is portable and can be hung over the side of a ship at sea where most convenient to embark anyone from a boat. It consists (fig. 5–4) of two pairs of side-ropes made of chain, wire or cordage, which are rove through—and support each end of—a series of wooden treads; it should reach from the gunwale or the top of the bulwarks to just above the gunwale of the boat.

The treads, usually about 1 ft 9 in. long, 5 in. broad and 1⅜ in. thick, are spaced at intervals of about 9 inches, and they should be fitted in the side-ropes so that they are horizontal, both fore-and-aft and athwartships, and are prevented from twisting. The top of the ladder is secured by shackles to eyeplates on the ship's side at deck level, and never to guardrails. In ships with a high freeboard the ladder should be kept from twisting by 4-ft battens lashed across the lower half of the ladder at about 10-ft intervals. These ladders are not usually provided with manropes, because the climber should grasp the side-ropes or the hand-holes cut in the treads, but in a seaway a lifeline should always be bent round the climber and tended on deck.

Fig. 5-4(i) shows a type of telescopic ladder provided in warships. The two pairs of side-ropes are of ¼-in. rigging chain, fitted with long links where the chain passes through the treads. The treads are secured to the long links by clenched pins passing through the treads. The whole ladder is telescoped for hoisting in or out or it may be triced up to a convenient height by a lanyard passing through the centre of all the treads; the lanyard is finished with a Turk's

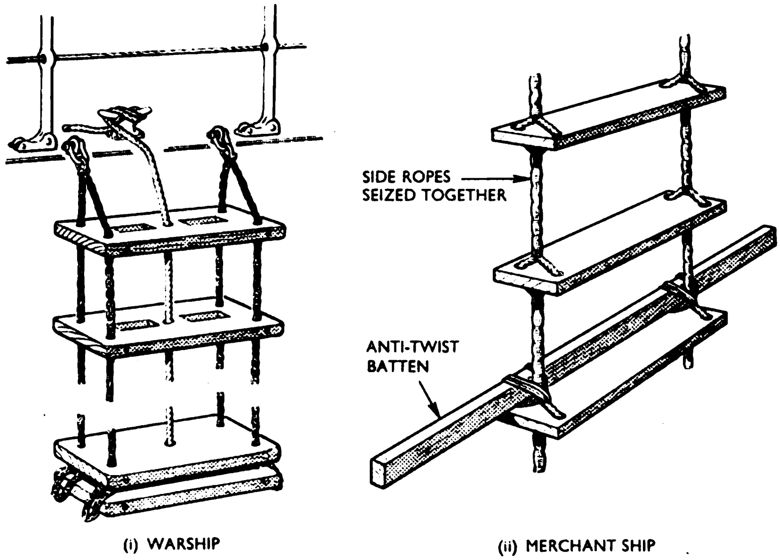


FIG. 5–4. Jumping ladders

head below the bottom tread. All except the bottom three Canadian-elm treads have two handholes.

Fig. 5–4(ii) shows a type of ladder used in merchant ships. It has two pairs of wire or cordage side-ropes, each pair being married and seized together between the treads and as close as possible to them to ensure that they are kept square and as rigid as possible.

Jumping (Jacob's) ladders

These ladders are constructed from F.S.W.R. strings 12 in. apart and 15 in. × 1¾ in. Canadian elm rounds. The rounds are inserted into the wire rope at 12-in. centres, so that three strands are on each side, and then wire seizings are placed above and below to hold the rounds in position. When the ladder is used in conjunction with boat booms a round thimble is seized in the bight of the wire, to which is secured the lazy painter of a boat.

These ladders are also fitted at some hatches provided with sloping ladders which are on the escape route from manned compartments and accommodation spaces, or on the main line of communication. They are shackled at their upper ends to eyeplates and are stowed rolled until required, when their lower ends are secured to eyeplates by cordage tails. If these ladders are used against a vertical bulkhead a pad should be secured between the top of the ladder and the bulkhead so that the ladder lies away from the bulkhead and provides better hand and foot holds.

Brows

These are normally only supplied to destroyers and below and are a type of portable walkway constructed of either wood or aluminium, with stanchions and guard wires which can be unshipped when the brow is not in use. The purpose

of a ship's brow is to provide a gangway between two ships berthed alongside each other, or between ship and shore when no dockyard brow is available (at some small commercial ports).

When ships are berthed alongside in a naval dockyard they are supplied with larger and heavier brows. At non-tidal berths the dockyard is responsible for securing the inboard end, whereas at tidal berths the dockyard is responsible for seeing that the inboard end is properly secured by ship's staff.

Safety measures. When ships are berthed alongside each other it is the responsibility of the outer ship—or of the last ship to secure, if at a buoy—to supply a brow and the proper stanchions, leeboards, etc.; but it is the responsibility of *both* ships to ensure that their end of the brow is properly tended and secured, and that any gap between the ship's guardrails and the guard wires of the brow is filled.

When a brow is positioned above a catamaran a net should be rigged underneath it.

The lashings which secure a brow should be secured to eyeplates, bollards, or other permanent fittings, and never to stanchions; and the brow must be kept clear of Nylon-coated stanchions.

A mat, fender, or other suitable material used as a Scotchman, should be placed under the end of a brow which is in contact with the deck; if a brow is fitted with a roller, a sheet of metal should be placed over the area of movement, and a guard fitted or notice displayed warning people of the danger as the brow rolls with the movement of the ship.

The approaches to the jetty end of a brow should be kept clear of obstacles, and at night *all* brows should be well illuminated.

No one, other than those responsible for placing it, is allowed to cross a brow until it is secured and the guardrails are correctly set up.

A ship in dry dock presents a particular risk to personnel when they cross a brow, and for this reason added safety measures are necessary. The stanchions and guard chains which surround the dock must always be in position. If for any reason their removal is necessary, the gap should be patrolled by a sentry until they are replaced. At night these stanchions and chains should never be unshipped, the approaches from the dockside to the brow should be kept clear, and the whole brow must be fully illuminated. Particular attention should be paid to the dockside chains and ship's guardrails where they are hitched to the guard wires on each side of the brow. When the angle of the brow necessitates the use of blocks or steps, they should be fitted with improvised stanchions and handrails of adequate strength. All guardrail slips are to be moused with seizing wire before entering dry dock, and these mousings are not to be removed until the ship is clear of the dock.

DAVITS

The three main types of boats' davit used in the Fleet are described in Volume I; the Merchant Navy gravity-type boat's davit is described in Volume III, and in this section will be a description of general-purpose and ammunitioning davits, the special-purpose davit, and the modern-type gravity and single-pivot torque davits fitted in new-construction ships.

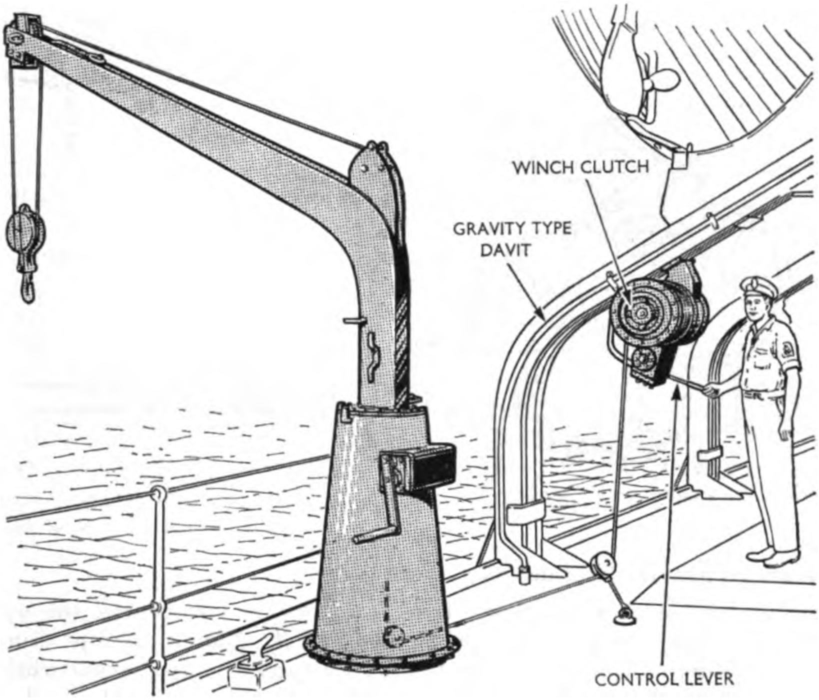


FIG. 5–5. General-purpose and ammunitioning davit

General-purpose and ammunitioning davits

Normally, these two types of davit (fig. 5–5) are identical, portable and interchangeable, and where this is so the safe working load of the davit should always be that of a davit employed handling ammunition.

When used in conjunction with accommodation ladders davits are usually hinged at deck level to stow flat, and are fitted with eyeplates to take the guys and pendant. When davits are used for striking down ammunition and stores a band is fitted at the heel, with a link to take a leading block; and guys or other locking devices are fitted to hold the davit in its correct position while the load is being hoisted or lowered.

Special-purpose davits

Torpedo, minesweeping, and other purpose davits are of a more permanent nature than the davits described above. Each davit has a watertight rectangular arm or post sited within a pedestal. The davit is trained by means of a worm wheel drive and its purchase of wire can either be incorporated within the pedestal fitting (fig. 5–6) or be led from the pedestal to a convenient winch. It is important that whenever a load is on the davit the latter is trained exactly to plumb the load.

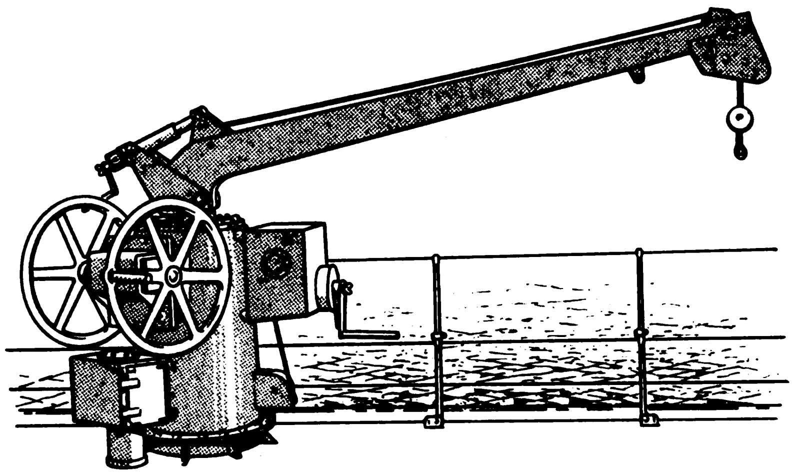


FIG. 5–6. Special-purpose davit

Overhead gravity boat davits

Two types of these overhead davits are fitted in men-of-war, the main difference being in the positions of the hydraulic machinery and rope drums. Both types are designed to handle 25-ft motor cutters or 27-ft motor whalers with a working load of 2½ tons. Each davit (figs. 5–7, 5–8) consists of a trackway of two channels curving inwards from the deck edge, and a cradle fitted with rollers running inside the trackway. The davits operate in two stages—the movement of the cradle down or up the trackway, and the movement of the boat down or up when the cradle is at the lowering position. Both stages are controlled by the 2¼-in. E.S.F.S.W.R. falls.

Disregarding the position of the rope drums and hydraulic motor (which are attached to the trackway), in both types of davit each single-wire fall passes round an intermediate sheave, through a tube and over the top sheave (all inside the cradle); it then passes through a stirrup hinged at the end of the cradle and terminates in a tapered ferrule to which are shackled a number of links and a special link for attachment to the hook of the boat's slings. Two tusks projecting from the under side of the cradle end fit underneath the ferrule when the cradle is raised.

The cradles are locked in the raised position by trigger levers mounted on the trackways engaging with pins on the cradles when the griping wires, shackled to the ends of the levers, are in tension. The boat is then carried on the keel rests; it lies against the gunwale chocks and the tension in the falls can be released. Pointers on the trackway and cradle show the stowed position. The cradles can also be locked to the trackways by passing stop pins through holes in both.

Lowering action. On slipping the gripes, the triggers automatically release the cradles, allowing them to be lowered by power or gravity. The cradles move down the straight part of the trackways and the rollers keep them vertical until the lower rollers pass the bend, when the cradle heads move outboard to swing

the boat clear of the ship's side and the boat leaves the cradles and hangs on the ferrules supported by the tusks. When the cradles are near the outermost position, the ferrules leave the tusks and the weight of the boat is transferred to the falls; further movement of the falls lowers the boat, because the cradles have reached their lower stops.

Raising action. The boat is raised until the ferrules strike the stirrups and further movement of the falls moves the cradles inboard until the pin on the cradle engages with the trigger lever. The hydraulic motor is then stopped and the stop pins are inserted in the trackways.

Rope drums and hydraulic motor. When the rope drums are fitted at the head of the trackways, the hydraulic motor is fitted to the after drum and the foremost drum is coupled to the after drum (fig. 5–7). When both rope drums and hydraulic winch are fitted near the base of one trackway, reeling gear is fitted at the head of each trackway to ensure that the falls between the rope drums and the sheaves of the reeling gear are always taut; otherwise riding turns will appear on the drums when there is no weight on the falls (fig. 5–8). The adjustment of the reeling gear is most important, and the instructions in the maker's handbook must be carried out.

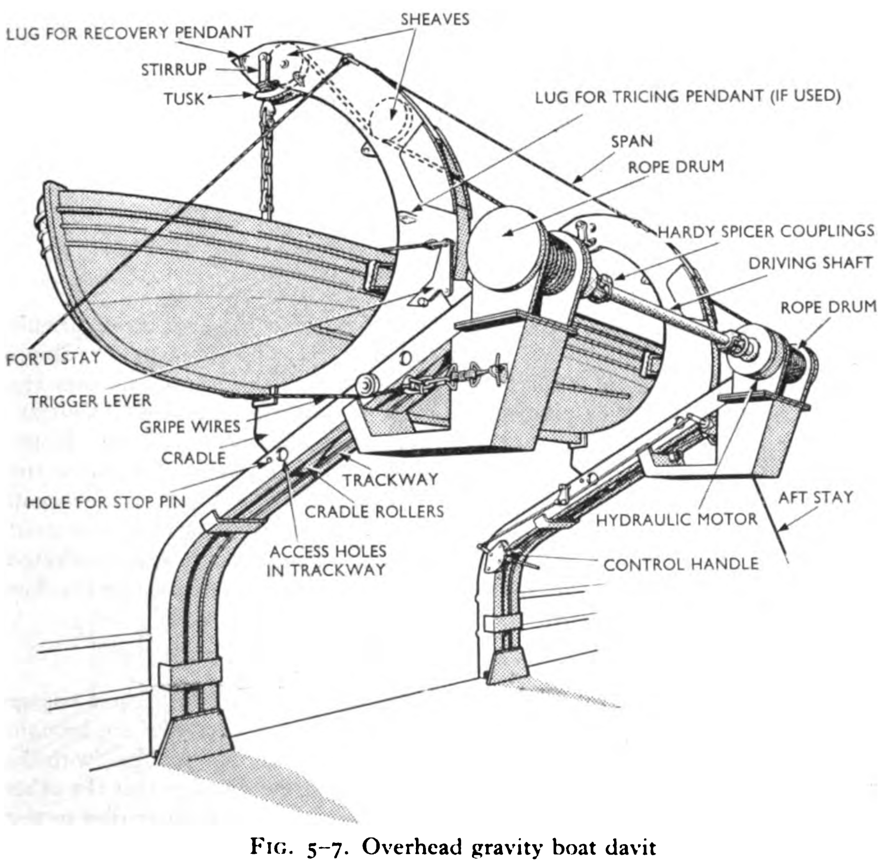


FIG. 5–7. Overhead gravity boat davit

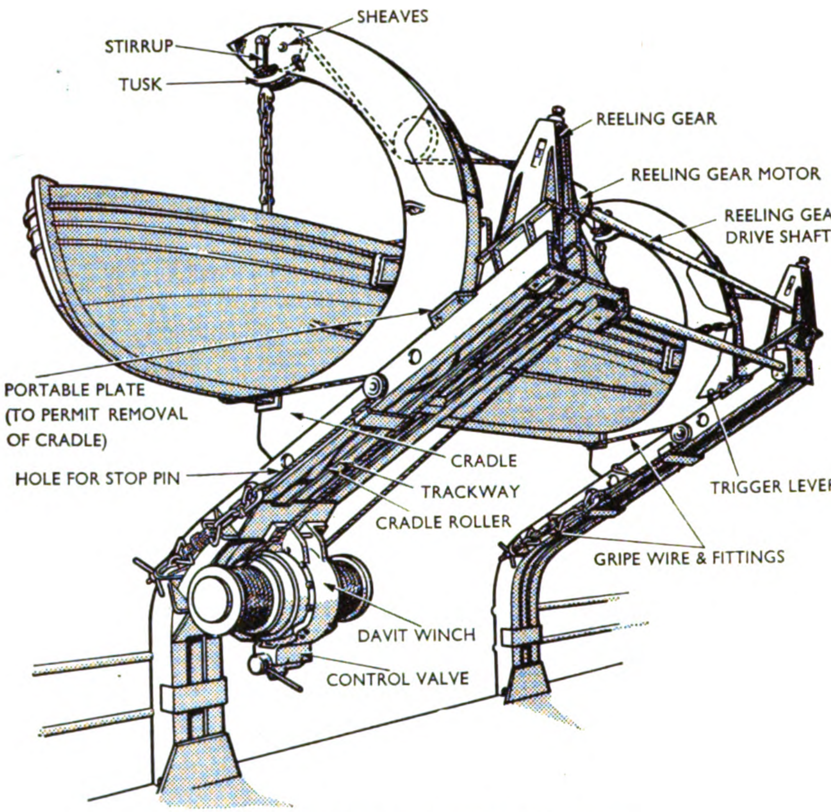


FIG. 5–8. Overhead gravity boat davit

Hydraulic motor control. The control valve is fitted close to the hydraulic motor and operated by a control handle at a convenient height nearer the ship's side; when the motor is at the head of the trackway the handle operates the control valve by rod. The control valve has five positions—'Hoist', 'Neutral', 'Gravity lower', 'Neutral' and 'Power lower', in that order. In the 'Hoist' position oil flows through the motor to exhaust. In the 'Neutral' positions the oil is shut off the motor and the motor stops, sustaining the load (a very small creep may be expected). In the 'Gravity lower' position the exhaust is connected to the inlet, providing free circulation for the oil in the motor; braking is effected by restricting or stopping the circulation. In the 'Power lower' position the flow of oil in the motor is reversed.

Adjustment of falls. The falls should be adjusted so that the triggers engage simultaneously. Adjustment is carried out as follows: The cradles are brought inboard until the cradle with the shorter fall is in the stowed position, with the trigger engaged and the stop pin inserted. Measure the distance that the other cradle must be moved for its trigger to engage, and lower both cradles to rest on the stop pins. One of the two drums is adjusted on the shaft, being secured

by six shoulder screws in a choice of holes giving a minimum adjustment of $\frac{1}{8}$ in. The unused holes are filled with screwed plugs.

Single-pivot torque boat davits

These davits (fig. 5–9) are spring-assisted in the initial luffing movement, so they are gravity-type davits. The whole operation is controlled by the two single-wire falls: the first movement on lowering allows the davits to be forced outwards by the *powerstats*, which are spring cylinders fixed to the davits, until the centre of gravity of the davits is beyond the pivots; further movement allows the davits to turn out under gravity until the ferrule at the end of each fall slips away from the supporting tusks and the movement of the falls then lowers the boat.

When hoisting, the boat is raised until the tops of the ferrules strike the stirrups hinged at the davit heads; further movement of the falls is then transferred to the davits and the davits and boat begin to turn inwards, while the tusks fork underneath the ferrules to support the boat. When the boat is fully turned in it should be just clear of the keel chocks and is then griped to the gunwale chocks by two wire gripes attached to the davit's standing structure. Jackstays are secured to the standing structure and pass over sheaves on the davits to positions in the ship's side near the waterline.

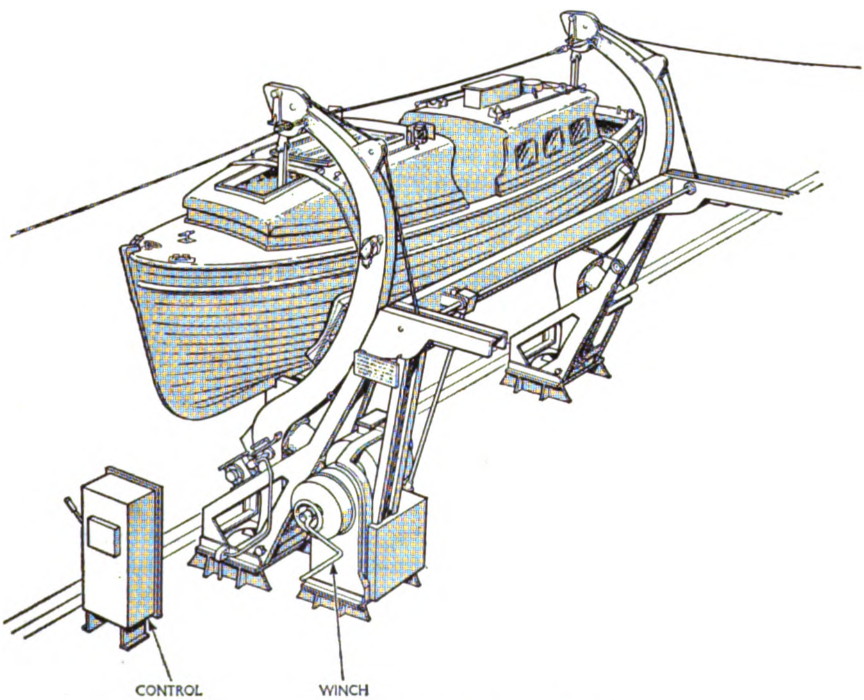


FIG. 5–9. Single-pivot torque boat davit

The falls. Each fall is a 1¾-in. F.S.W.R. anchored by bolted clamp in one half of the winch rope drum, which is grooved right- and left-handed to take the whole length of both falls in one layer. The fall then passes through the *reeling gear*, over the two davit sheaves, through the foot of the stirrup and ends in a weighted and specially-shaped ferrule. A special linkage joins the ferrule to the hook of the boat's Robinson disengaging gear.

Reeling gear. The purpose of this gear is to keep the falls in tension between the winch drum and the gear so that the falls will pay out readily when they are light (i.e. with no boat attached). The gear consists of two rope-gripping sheaves held together by a compression spring and driven by rod gearing from the winch. A slipping clutch in the rod gearing prevents overloading of the gear; but if the falls and grooves of the reeling sheaves are allowed to become dry and rusty with salt deposit, and too much pressure is applied to nip the falls, it is possible to lower and raise the boat through the reeling gear, which is neither intended nor designed for this purpose. Great care must therefore be taken in its maintenance and adjustment as given in the maker's handbook.

Drum wire tensioning gear. The turns of wire on the drum are kept in their grooves by a rubber-sleeved roller, which presses against the turns to keep them from overriding when the falls are light.

Winch and motor. These are situated together near the foot of the foremost davit. The winch is driven by a 3-speed electric motor through two reductions of spur gearing. The motor shaft is connected to the *lowering speed control box* (which contains the main centrifugal brake) and the first stage of the reduction gear by a centrifugal motor clutch, which is automatically declutched when the motor is at rest. The winch shaft also drives the reeling gear.

Controller. The winch is controlled by a lever and selection gate at the controller, which is positioned at the ship's side so that the operator can see the boat throughout the operation of hoisting or lowering. A 'push-button' emergency stop switch is provided on top of the controller, also a reset push at the side of the switch. When the button has been pressed the operator must move the control lever to 'Stop' and then use the reset push.

Power hoisting. There are three gate positions of the lever for power hoisting:

Hoist 1	giving a fall speed of	13 ft/min.
Hoist 2	,, ,, ,, ,,	28 ,,
Hoist top	,, ,, ,, ,,	40 ,,

The electric brake, incorporated in the centrifugal motor clutch, is automatically released when the lever is put to 'Hoist 1' and remains off through 'Hoist 2' and 'Hoist top'. If power fails the brake is automatically applied.

Lowering is normally by gravity and is done simply by lifting the weighted mechanical brake lever, either directly or remotely by moving the control lever to the 'Gravity lower' position. The boat will then be turned out and lowered by gravity, because the motor is declutched when stopped.

Lowering by power is for *light falls only.* The control lever has first to be moved to the 'Light fall power' gate by withdrawing the safety catch at the end of the gravity gate. Movement of the lever now releases the electric brake and the falls are paid out by power, assisted by the reeling gear.

Summary of Control Lever Positions

Position	Brake Electrical	Brake Mechanical	Motor	Speed
Stop (neutral)	On	On	Declutched	Nil
Hoist 1	Off	On	Clutched in	13 ft/min
Hoist 2	Off	On	Clutched in	28 ft/min
Hoist top	Off	On	Clutched in	40 ft/min
Lower gravity	On	Off	Declutched	100 ft/min (approx.)
Lower power	Off	On	Clutched in	13/28/40 ft/min

Manual operation. The winch can be operated manually by shipping a handle over the end of the brake shaft; but *power must first be switched off*, even when there is a power failure, because power may be restored with unfortunate consequences to the manual operator. A ratchet within the main brake prevents the winch from running backwards.

Precautions before operating by power or gravity

1. Both gripes must be slipped, and withdrawn over the boat if there is time.
2. Check that the manual operation handle is not shipped.
3. Hinge down the guardrail stanchions if there is any movement on the ship.
4. Davit guys must be free, i.e. they must not restrict the movement of the davits.
5. Power main switch must be 'On'.

Maintenance. The need for regular cleaning and lubrication and inspection of the falls cannot be too highly stressed. The points requiring attention are listed in the maker's handbook.

CHAPTER 6

Advanced Rigging

In Volume I the seaman was introduced to some of the basic rigging gear. In this chapter blocks, slinging, cranes, derricks and winches are described, and the seaman will be taught how to find the strength of fittings and gear, how to estimate the stresses in a rig, and how to handle heavy weights by both orthodox and extempore methods. Replenishment-at-sea rigs are described in Chapter 11, and the items of rigging used with anchors, cables and towing are included in Chapters 9 and 10 and in Appendixes I and II.

STRENGTHS OF RIGGING FITTINGS AND GEAR

The *safe working load* of any fitting or gear is the maximum load it is designed to bear in practice, and is fixed as a definite proportion of the load at which it will break, known as the *breaking strength.* The ratio of the breaking strength to the safe working load is called the *factor of safety*, and gives a measure of the ability of the gear to stand up to its work. A table of factors is included in Appendix I (page 587).

All gear built up of individual units is itself designed for a definite safe working load, and each unit must be strong enough to withstand that load; otherwise the strength of the whole is weakened. Similarly, any unit that is unnecessarily strong may reduce the efficiency of the whole if it is heavier than is necessary. The safe working load of each part must therefore not be less than—and should be no more than—that of the whole system.

Before being accepted for the Royal Navy all but the most unimportant fittings are subjected to a *proof load*, which they must bear without injury. The proof load also is based upon the breaking strength, and normally is twice the safe working load. The proof tests of some important fittings are repeated at intervals of one or two years, because, as is described in the next paragraph, the strength of a metal object may decrease. After each test the fitting is subjected to a careful examination, and if it shows no sign of damage it is then stamped with the place, date and proof load applied; a fitting marked 'Po.10T.2.4.65', for example, was tested at Portsmouth to 10 tons on the 2nd April, 1965.

Apart from normal wear and corrosion, a metal fitting which is amply strong when new may become gradually weakened by induced brittleness, sometimes called *fatigue*. Generally speaking, fatigue is caused by suddenly-applied loads, particularly when applied from opposite directions alternately, and by sharp blows such as those caused by dropping the fitting or knocking it about. Continued ill-treatment in this manner will ultimately result in the cracking and fracture of the metal. Brittleness can be corrected by a heat treatment

called *normalising*, which restores the metal to its previous condition but will not make good any cracks that may have developed in it.

The factor of safety, and therefore the safe working load of a fitting, are usually fixed by the designers according to the anticipated wear and fatigue and proposed intervals between proof tests: the less frequent the tests the higher must be the factor of safety. Allowance is also made for the fact that if a load is applied suddenly the fitting is subjected momentarily to a stress which may be as much as twice that of its normal safe working load. As well as reducing the margin of safety, such a stress causes fatigue which, in the case of a metal fitting stressed to about half the breaking strength, will cause permanent distortion. The margin of safety afforded by the factor of safety is therefore much less in practice than it appears to be.

Safe working loads of fittings used in the Royal Navy are fixed by the Navy Department, and, generally speaking, their factors of safety are greater than those assessed in commercial practice, where lightness of gear, particularly for cargo work, is so important. For example, the heavy derrick of many a well-found freighter will, when hoisting its full load, have parts of its gear stressed well beyond the limits allowed by Navy Department practice; but, because of very frequent maintenance, inspection and testing, this is commercially acceptable.

Though gear should never normally be stressed beyond its safe working load, occasions arise (such as in salvage work) when exceptional stresses must be accepted; and, provided that the additional wear and fatigue are taken into account, stresses which would be dangerous if continued as a regular practice can very occasionally be accepted. Generally speaking, the more recently any gear has been tested, the less it has been used since that test; and the better the maintenance the greater, within obvious limits, is the load to which it can be subjected. The correct assessment of the load and of the risks involved in subjecting the gear to it require sound judgment and considerable experience.

All rigging items supplied to the Royal Navy are listed in B.R. 810, *Rate Book of Naval Stores*, and details can usually be found in the complementary numbered schedules, which are small pamphlets published by the Director of Naval Construction; when included, the appropriate schedule is shown alongside the letter C or D in the description column on each page. For example, the heading 'C5—Smith's Work' indicates that the gear shown below is included in Schedule 5, which is the specification for smith's work. A selection of items used in rigging is given in Appendix I and listed so as to enable the gear to be matched for strength or size. The various items can be described by their proof loads, sizes, or pattern numbers (e.g. 5-ton bow shackle, 1-inch bow shackle, or bow shackle Patt. 5346). The method of measuring the size of each fitting, and other details, are given below. The pattern number is always required when drawing gear from Naval Stores. It must be remembered that the proof load stamped on each fitting is double the safe working load; in other words, *a 5-ton shackle is required for a 2½-ton safe working load.*

The rules given below (and grouped collectively in Appendix I) for calculating the approximate safe working load of hooks, shackles and similar fittings and their factors of safety assume that they are made of the material quoted; fittings

made of higher-grade metal will, of course, be stronger. In all cases W is in tons, and all dimensions are in inches.

Shackles

The size quoted for a straight or a bow-shaped shackle used with rigging is the diameter of the metal at the crown. The safe working load of a straight shackle is found from $W = 4d^2$, and that of a bow-shaped shackle from $W = 2{\cdot}5d^2$. (The sizes quoted for a shackle and other gear which form part of the outfit of anchors and cables are not their own measurements, but those of the cable for which they are designed.) After manufacture each shackle is tested to the specified proof load, and the maximum safe working load is half this amount. The factor of safety for most shackles is 6.

Thimbles

These can be made of iron or steel, but those used for wire rope are usually of steel; the pattern number is always stamped on each.

The size of a thimble is usually quoted as that of the rope for which it is designed, but this is complicated by the fact that a wire rope requires a snug fit, whereas most natural fibre ropes need a slack fit to allow room for the rope to swell, and so a larger thimble is used for them than for a wire rope of similar size. Cordage is also often larger than its standard size owing to the tolerance allowed in manufacture. The size of rope which a thimble will take depends on both the width and depth of the groove, but a fair practical assumption is that where d is the width of the groove, it will be $3d$ for wire rope, $2{\cdot}5d$ for served wire rope, and somewhere between the two for natural fibre rope.

It is recommended on page 112 that wire rope should not be served before being broken-in round a thimble, but hawsers supplied from commercial sources may still be found to have the wire served.

A thimble is properly described by its size and type (e.g. '1-inch, heart-shaped, open, steel thimble'); the dimensions supplied can be found from the *Rate Book of Naval Stores* and in Appendix II. As the strength of rigging or any other equipment is not affected by the strength of any thimble fitted in it, thimbles have no specified safe working load, but a steel thimble should not be distorted by a pull of up to $\frac{c^2}{2}$ tons, where c is the circumference of the wire for which the thimble is designed; and it will usually crush at about $\frac{3c^2}{4}$ tons. Iron thimbles are weaker, but they are adequate for natural fibre rope.

Hooks

The quoted size of a hook is the diameter of the metal at its crown. The safe working load can be found approximately from the formula $W = \frac{d^2}{2}$, where d is the diameter of the *back* (not the crown) of the hook, provided that the internal diameter divided by d is less than $2{\cdot}5$.

All except minor miscellaneous hooks (such as hammock hooks and can hooks) are tested after manufacture to a specified proof load, and the safe working load is half the proof load. Hooks for boats' slings also have a specified failing load, and a percentage are tested to destruction; their factor of safety is approximately 5·5.

Eyeplates

Stamped steel eyeplates are used for securing an eye to a metal structure; riveting is considered the more reliable method, the rivets being always stronger than the eye. It is Navy Department policy that welding should not be used for important eyeplates unless they can be tested in position. The size quoted for an eyeplate is the diameter of the metal forming its eye. The safe working load is given approximately by the formula $W = 6d^2$.

After manufacture every eyeplate is tested to the specified proof load, and the safe working load is half this amount. Its factor of safety is 4.

Eyebolts

Wrought iron or mild steel eyebolts are used for attaching eyes to a wooden structure; they are of two types, the *screwed* and the *driven*. Screwed eyebolts are much the stronger and are used for any but the lightest loads; they are drawn from store double-ended, in pairs; they are cut to length and then threaded at the end. The size quoted for both types is the diameter of the metal composing the eye. When in use the safe working load of a screwed eyebolt is given approximately by the formula $W = 3d^2$. The driven eyebolt has no specified strength because of its uncertain hold when driven into wood.

All eyebolts are tested after manufacture to the specified proof load, and the safe working load is half this amount.

Ringbolts

A ringbolt is a screwed eyebolt with a ring or link attached; the metal forming the ring or link is of the same diameter as that of the eyebolt, but the ring or link is much the weaker of the two. The safe working load is that of the ring or link, and is found from the formula $W = 2d^2$. On completion of manufacture each ringbolt is tested to the specified proof load, and the safe working load is half this amount.

Rings

The size quoted for a ring is the diameter of the metal, and the approximate safe working load of a wrought iron ring can be found from the formula $W = 2d^2$. This formula holds good for most rings supplied to the Royal Navy whose internal diameter in the clear (D) is four times the diameter of the metal; but for rings whose internal diameter when divided by the diameter of the metal forming the ring is greater than 2·3, the formula $W = \frac{7d^3}{D}$ should be applied.

Each ring is tested after manufacture to the specified proof load, and the safe working load is half this amount. Of those supplied for boats' slings a percentage are tested to destruction and must give a factor of safety of 6.

Union plates

These are metal plates through which three or four holes are drilled to enable the eyes of wire ropes or ends of chain to be shackled to them. The *Rate Book of Naval Stores* describes them as *eyeplates* (three-eyed or four-eyed), and a three-eyed union plate is often referred to as a 'monkey face' or 'shamrock plate'. Union plates are tested after manufacture to the specified proof loads, and their safe working loads are half these amounts.

Rigging screws

A detailed description of rigging screws is given in Volume I; they are proof-tested after manufacture and their safe working loads are half their proof loads; their factor of safety is 6.

Rigging chain

This unstudded chain is often used in rigging equipment—for commercial crane whips and part of derrick standing topping lifts, for example. It is also used in light mooring ground work for danbuoys and surveying beacons. Pattern numbers and sizes are given in B.R. 810, *Rate Book of Naval Stores*. The formula for finding the approximate safe working load of chain supplied to the Royal Navy is $W = 5d^2$.

Chain is tested after manufacture to the specified proof load, and the safe working load is half this amount. However, if it is knocked about or subjected to shock loading (both of which should be avoided, if possible) it must be normalised periodically, or returned to store; otherwise it may well part from fatigue.

Rigging slips

These small iron slips are supplied to the Royal Navy in various sizes for general purposes. The approximate safe working load can be found from the formula $W = 5d^2$, where d is the diameter of the link. They are proof-tested and their safe working loads are half these amounts.

BLOCKS

Volume I described the types of blocks and the parts of a block; here the various blocks used by the Royal Navy and the Merchant Navy, purchases and tackles, and geared blocks will be described. Further information regarding tackles, when using extempore gear, will be given later in this chapter, and formulae and tables of interest to this section are contained in Appendix I.

GENERAL INFORMATION

After manufacture, alteration or repair every block is tested to the proof load which it must bear without injury. In addition, certain important blocks are tested periodically. The proof load depends on the designed strength of the block, which s laid down in its specification; the test is applied so that the

crown of the block and the pin of the sheaves are subjected to this load. The record of each test is stamped on the crown of I.B. blocks and on the shell or binding of clump and metal blocks.

Royal Navy

The safe working load of a block is the weight of hoist for which it can be used without being stressed beyond half its proof load, and without the safe working load of the rope or fall being exceeded. Nearly all blocks are much stronger than the rope for which they are designed; therefore the safe working load of a tackle is nearly always limited by the safe working load of the fall. But the safe working load also depends on the way the block is used; for example, the safe working load of a block used as the upper or standing block of a purchase will not be the same when it is used as the lower or moving block of the same purchase. With a few exceptions safe working loads of all blocks are calculated for the following uses:

as a single whip (single blocks only);

as the upper (standing) block of a hoisting purchase (except when a becket is not fitted);

as the lower (moving) block of a hoisting purchase.

In these instances the purchase is assumed to be rove to disadvantage—that is, with its hauling part coming from the upper block—because when so rove the blocks are subjected to the greatest stress.

Snatch blocks have only one safe working load, because they are single blocks; and they *must never be used as leading blocks when safety of life is involved*, for example, in boats' falls or light jackstays.

Wooden clump blocks are not stamped with a safe working load, but the strength can generally be taken as being a quarter of the strength of an I.B. block used for the same size of rope.

Blocks which form part of a complete lifting system (such as a derrick) are also not marked with a safe working load, because it might be greater than the safe working load of the whole system and therefore might lead to misunderstanding and accident. In such cases the safe working load of the entire system is shown on a tally plate in the vicinity.

In addition to their proof loads, blocks used in the Royal Navy are marked with the pattern number, maker's name, year of manufacture, size of cordage or wire rope for which the block is designed and, discounting the two instances mentioned above, safe working load. The marking is on the sides or crown of the block (except the maker's name and year of manufacture of I.B. blocks, which are marked on the binding).

Where I.B. or steel blocks are used the standing part of the fall can be either secured to the metal becket provided for the purpose, shackled to an eyeplate at the davit head adjacent to the standing block of a boat's fall, or spliced round the eye at the crown of an I.B. block and the bight seized into the tail, enabling the purchase to be hove up *two blocks*.

Strops used for clump blocks are of wire rope, short-spliced, parcelled and served. They can be put on singly or on the bight (i.e. as a single or as a double strop), so that the seized-in thimble lies either at right-angles to the sheave or

in line with it. The correct length of the wire rope is found from the sum of once round the block, once round the thimble, once round the wire (these measurements would be doubled when making a double strop), and twice the tucking allowance.

The 10-inch and 11-inch clump blocks have double strops made from 1¼-inch wire rope, and the 12-inch and 13-inch sizes are similarly stropped using 1½-inch wire rope.

Merchant Navy

The various loads for blocks are laid down in the *Docks Regulations*. The safe working load is taken as being the maximum weight of hoist for which the block should be used, and takes no account of the strength of its fall; therefore it depends solely on the strength of the block and its employment.

Proof loads are authorised as follows: single blocks—four times the safe working load; multiple blocks with the safe working load up to and including 20 tons—twice the safe working load; multiple blocks with the safe working load over 20 tons and up to and including 40 tons—20 tons in excess of the safe working load; multiple blocks with the safe working load over 40 tons—one-and-a-half times the safe working load. It will therefore be seen that under the *Docks Regulations* a block is proved to a stress of from one-and-a-half to four times the maximum load it will bear when working at its maximum safe working load.

The *Docks Regulations* also prescribe that all blocks used in the Merchant Navy for hoisting and lowering must have their safe working loads plainly marked on them.

Basic maintenance

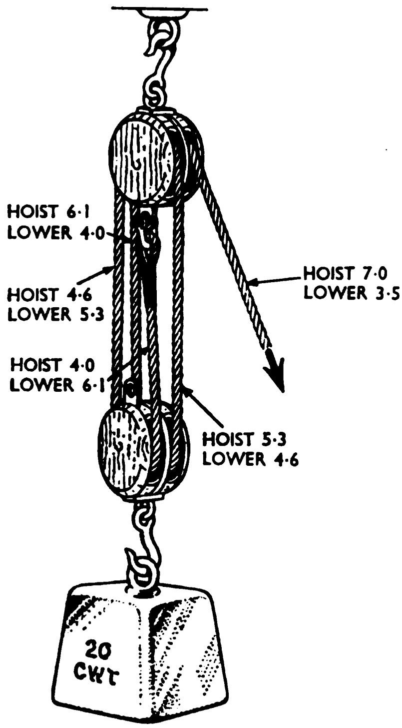
A great deal of time, trouble and temper will be saved if the pins of blocks (other than those with self-lubricating sheaves) are knocked out once every three months so that the bearings can be cleaned and oiled. Roller bearings, where fitted, are fixed in the sheave and can be plainly seen when the sheave is removed. They should be examined and filled with grease before reassembly.

It is the hall-mark of an ill-found ship when a block is heard to complain (squeak); for not only does it prove that maintenance is sadly lacking, but also that metal is biting into metal, with a resultant reduction of the block's strength.

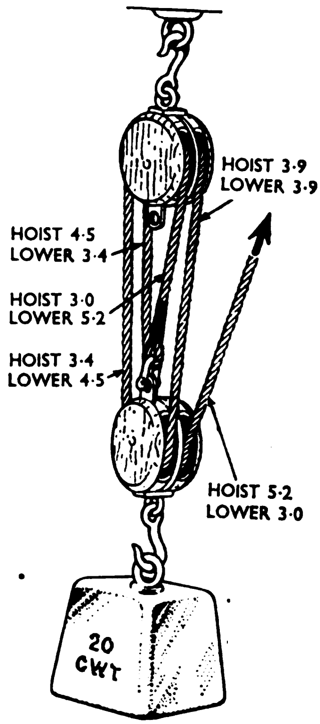
PURCHASES AND TACKLES

The stresses on the standing, running and hauling parts of the fall of a tackle depend to a certain extent upon the friction in the sheaves and in the moving parts of the fall. The amount of this friction will in turn depend upon the size of the fall and the sheaves, the number of sheaves in the tackle, whether the tackle is rove to advantage or disadvantage, and whether it is being used for hoisting, lowering or holding a load.

The general approximate rule for estimating the amount of friction set up in a tackle when hoisting a given weight is to allow one-tenth to one-eighth of the weight for every sheave in the tackle according to whether the tackle is well



(i) Disadvantage



(ii) Advantage

FIG. 6–1. Load (in cwt) on each part of a two-fold purchase when hoisting and lowering

made and in good condition or of poor quality and badly maintained. It is intended to assume that all tackles used in the Fleet are in good condition, so one-tenth of the weight for every sheave is now accepted as the rough rule. Therefore if one ton is to be lifted and there are six sheaves in the tackle, the total friction will amount to six-tenths of a ton, or 12 cwt. Friction occurs at each sheave, and each part of the fall will bear a different proportion of the load and so be differently stressed. When hoisting, the hauling part takes the greatest load and the load diminishes at each successive moving part; the standing part is the least stressed. When lowering, this situation is reversed, because the standing part takes the greatest load. When a tackle is holding a load still, the stress in each part will be between those to which they are subjected when hoisting and lowering. These effects of friction are illustrated in fig. 6–1, which shows the load on each part of a two-fold purchase in average condition when hoisting and lowering a load of 20 cwt.; they are also given in the table in Appendix I, which gives the velocity ratio, mechanical advantage and safe working load formulae for certain factors of safety of some of the commonly-used tackles (page 601).

Also directly connected with the problem of friction is the estimated pull required on the hauling part of a tackle to lift a given weight. In Appendix I a formula is provided (page 601) to assist in this calculation, and examples are

included which, it is hoped, will help the seaman to understand this subject.

Royal Navy blocks used in a tackle are stronger than the rope for which they are designed; therefore in all calculations connected with blocks, purchases and tackles the maximum safe working load is that of the fall and not of the block.

Provided that the safe working load of any part of the gear is not exceeded, a given mechanical advantage is obtained more efficiently by a combination of two small tackles than by one large one, because there are then fewer sheaves to cause loss by friction and the smaller tackles are lighter and much more easily handled.

A single part of rope when used for hoisting tends to untwist and cause its load to spin; in the same way a rope rove through a block will, when under strain, spin the block and put turns in the parts of the tackle. One such turn in the parts will increase the pull required on the hauling part of a tackle by about 40 per cent, and two or more turns will increase it immeasurably. This tendency of the block to spin can be countered by thorough footing the fall before reeving the tackle; or by the use of an anti-twister; or, as in the case of the lower blocks of boats' falls, by the handles fitted on the cheeks of the block; or, in a two-or three-fold purchase, by reeving the fall so that the sheaves will turn in opposite directions. The simplest form of anti-twister is a handspike placed between the parts, close to the block. If the block is out of reach and the tackle is being used horizontally the handle of a heavy mallet or sledge-hammer can be lashed across the crown of the block, and the weight of the head will then prevent the block from twisting. When this method is unsuitable a handspike can be lashed across the crown and secured by lines made fast to its ends.

Reeving a three-fold purchase by the method described below not only helps to prevent turns forming in the tackle, but, because the hauling part comes away from the centre sheave, also avoids any tendency for the block to cant sideways as the load comes on it. Let the block to which the standing part will be secured be called *A*, and the other *B*. Both should be laid tail to tail, *A* being on its edge with the sheaves vertical, and *B* on its cheek; the fall is then rove as follows:

1. down through the centre sheave of *A;*
2. from right to left through the lower sheave of *B;*
3. up through the left-hand sheave of *A;*
4. from left to right through the upper sheave of *B;*
5. down through the right-hand sheave of *A;*
6. from right to left through the centre sheave of *B;* and
7. finally secured to the becket of *A*.

Reeving a two-fold purchase in a similar way to the above can be done, but is not often necessary. The blocks are laid as before and, assuming that the becket of *A* happens to be on the right-hand side, the fall is rove as follows:

1. down through the right-hand sheave of *A;*
2. from right to left through the lower sheave of *B;*
3. up through the left-hand sheave of *A;*
4. from left to right through the upper sheave of *B;* and
5. finally secured to the becket of *A*.

Had the becket been on the left side of the block *A*, the fall would be rove in the reverse manner to that described.

Special purchases

The rule given in Appendix I (page 603) for finding the pull required on the hauling part of a tackle to lift a given weight is based on the friction found by actual experiment to occur in ordinary upperdeck tackles, but it is not applicable to special purchases such as the topping lift and purchase of a heavy derrick. In such purchases, which may be three-, four- or five-fold, friction has to be reduced to a minimum or they will not be able to lift their designed safe working loads efficiently and safely; their blocks are therefore of special design and have to be very carefully maintained and oiled.

The allowance for loss of efficiency due to friction is normally one-tenth of the weight being hoisted for each sheave in the tackle. This loss decreases with improved design and maintenance of the blocks and in a large special purchase it is reduced to one-twentieth or less; so the special formula given in Appendix I must be used.

GEARED BLOCKS

Geared blocks are mechanical purchases designed for lifting weights and have a number of advantages over the simple tackle. They usually consist of a sprocket, worked by an endless hand chain, which operates the load sprocket through some type of gearing; the load sprocket carries the load chain, to which the hoisting hook is attached. Those supplied for use in confined spaces have a lever and ratchet instead of the endless chain.

Geared blocks can be designed with a very large mechanical advantage and little friction, so that the full safe working load of the gear can usually be raised by one man. Blocks supplied to the Royal Navy have safe working loads of from a quarter of a ton to as much as 10 tons, but those of over 3 tons are not widely used. The mechanical advantage of the lever and ratchet purchase depends on the length of the lever, and the safe working load is therefore limited. Geared blocks are supplied with chain sufficient for a lift of 10 feet, and the lever type of purchase can raise its load between 5 and 6 feet.

All of these purchases are self-holding, i.e the load remains suspended when the operating hand chain or lever is released; but certain types are fitted with a gravity lowering device which enables the load to be lowered by its own weight, under control, at a steady speed of 25–30 feet per minute.

Geared blocks running on overhead rails are used for transporting heavy gear in workshops.

A complete list of geared blocks supplied to the Royal Navy, together with the lever and ratchet purchases, is given in B.R. 810, *Rate Book of Naval Stores*.

Details of geared blocks

These blocks vary in design, but are grouped into the three main classes described below.

1. *Spur-geared blocks*, which obtain their mechanical advantage through

various systems in which small pinions drive large toothed gear wheels. The loss due to friction is as small as from 5 to 10 per cent, which compares with the 37 per cent lost in an upperdeck three-fold purchase.

There being so little friction, some device such as that shown in fig. 6–2(ii) is necessary to make the gear self-holding. The driving sprocket wheel is fitted on a screw-thread cut in the end of its spindle, along which it moves out and in as it is rotated one way or the other. The ratchet wheel is free on the spindle, but as it is fitted with a pawl it can revolve only in the hoisting direction. The thrust collar is made in one piece with the spindle.

When revolved in the hoisting direction the sprocket moves along its screw thread until it comes up against the ratchet wheel. This, in time, is squeezed against the friction washer and thrust collar so that the whole assembly revolves together. When no longer being hoisted the load is held by the pawl and by the friction between the ratchet wheel and the thrust collar. When the sprocket wheel is turned in the lowering direction it moves away from the ratchet, and, the thrust collar being then freed from the ratchet wheel, the load descends by its own weight until the spindle has revolved a similar amount and then again brings the sprocket wheel hard up against the ratchet.

2. *Blocks worked by a worm and wormwheel*, in which one revolution of the worm moves the wheel one tooth and therefore the mechanical advantage can be measured by the number of teeth in the wormwheel, less a small allowance for friction. A worm and wormwheel can be designed to be automatically self-

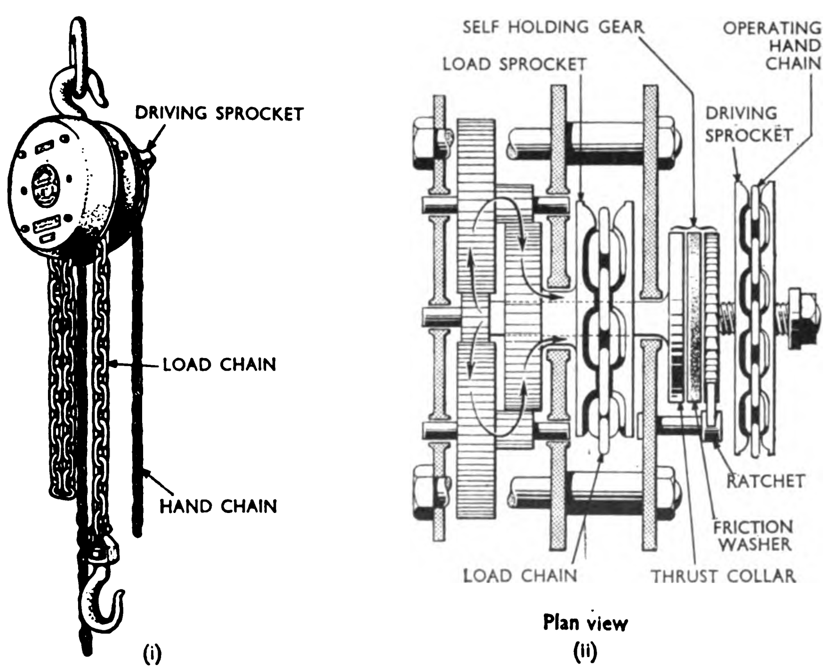


FIG. 6–2. Spur-geared block

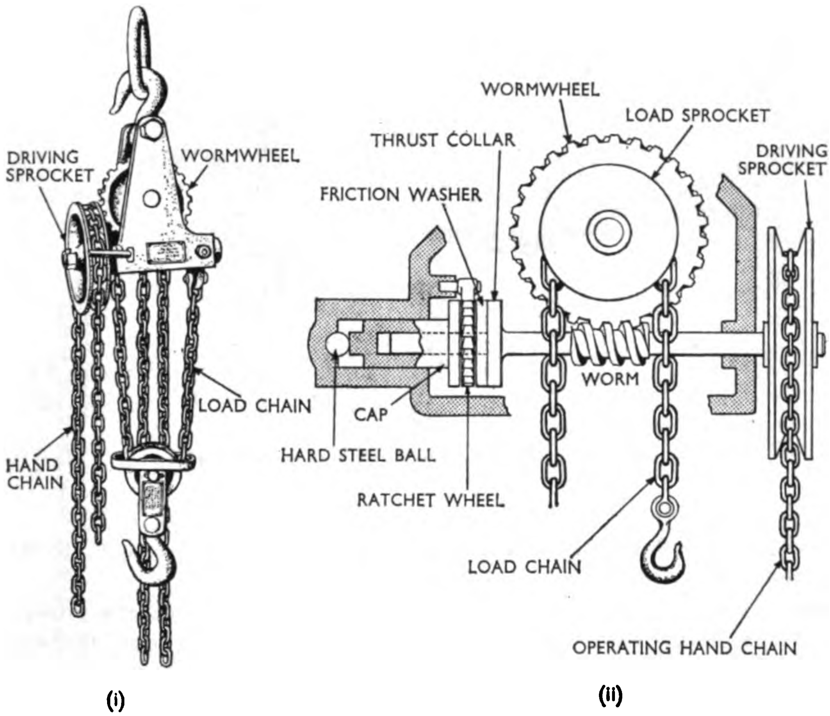


FIG. 6–3. Worm and wormwheel block

holding, but the worm must then be inconveniently large for a geared block; the small worm used in geared blocks is not self-holding, and it is therefore necessary to incorporate a device similar to that used with the spur-geared blocks.

In this form of purchase the driving sprocket is fixed to the worm spindle (fig. 6–3(ii)). Rotation in the hoisting direction forces the worm to the left and jams the ratchet and friction washers against the cap, so that all then revolve together. When at rest the weight hanging from the load sprocket wheel still forces the spindle hard to the left; the ratchet is then held by its pawl, and the friction between the ratchet and thrust collar makes the gear self-holding. Rotation of the driving sprocket in the lowering direction moves the spindle over to the right; this releases the friction gear so that the load can be lowered.

An alternative self-holding gear, illustrated in fig. 6–4, consists of a disc one side of which takes up against the driving sprocket so that it forms a frictional brake. This disc has wedges on its other side which engage with corresponding wedges attached to the shell of the block. The sprocket is fixed to the driving spindle, but the disc is free. Movement of the sprocket in the hoisting direction forces the spindle to the left and so pulls the sprocket up against the disc, and the wedges then tend to release each other so that the brake does not bind. When hoisting ceases the spindle is still forced to the left, but, should the load take charge and tend to run back, the wedges jam the disc and sprocket hard together, thereby making the gear self-holding. Movement of the driving

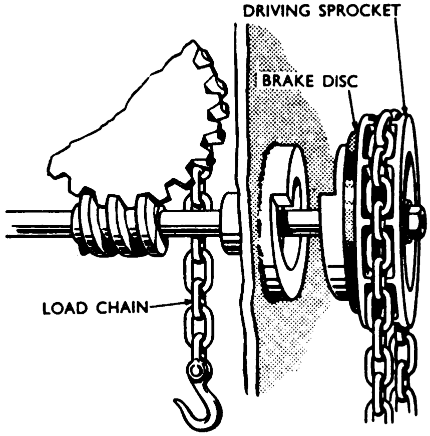


FIG. 6–4. Alternative self-holding gear for worm and wormwheel block

sprocket in the lowering direction moves the spindle to the right, thereby releasing the brake.

Blocks fitted with gravity lowering devices are all of the worm and wormwheel type. The driving sprocket can be either keyed to, or freed from, the worm spindle by means of a clutch. As can be seen from fig. 6–5, the worm spindle

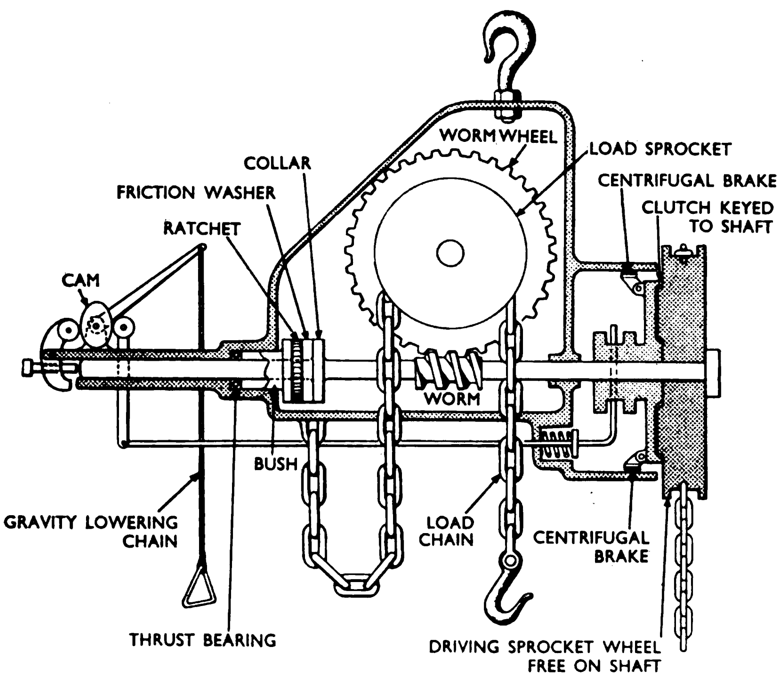


FIG. 6–5. Worm and wormwheel block fitted with gravity lowering devices

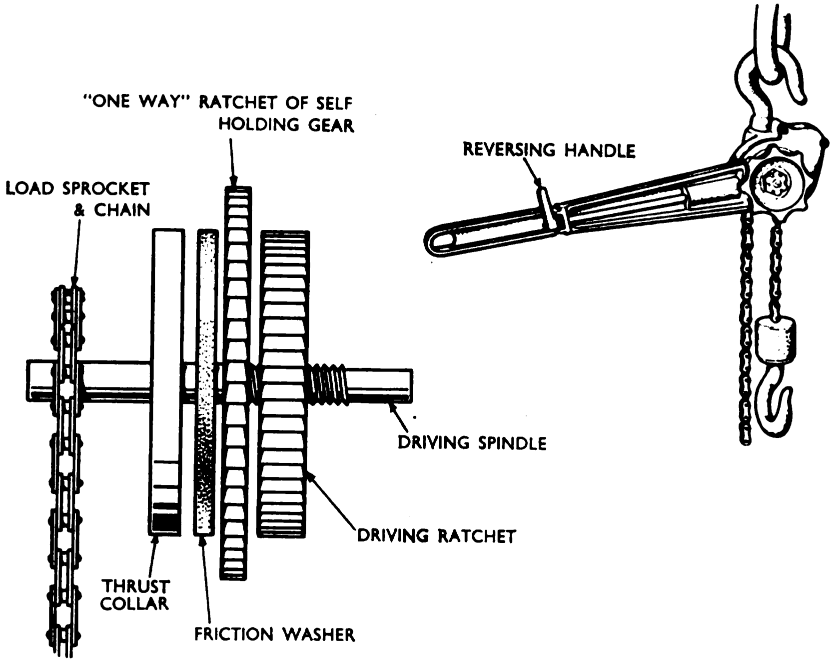


FIG. 6–6. Lever and ratchet purchase

protrudes through the self-holding gear, and a loose bush and thrust bearing have been incorporated. This device has the dual purpose of unclutching the driving sprocket and of forcing the spindle to the right so that the frictional self-holding gear is released. The load is then free to lower, and its rate of lowering is governed by a centrifugal brake incorporated in the clutch.

3. The *lever and ratchet purchase* (fig. 6–6), in which the mechanical advantage is gained by a simple lever worked like a pump handle. When the lever is so worked a pawl mounted on it revolves a ratchet wheel, and the pawl can be reversed so that the wheel can be turned in either direction. The ratchet wheel is fitted on a screw thread cut in the spindle of the load sprocket, and it drives this spindle through a self-holding gear similar in operation to that of spur-toothed blocks.

Safety measures

When geared blocks of an approved type are used for opening and closing heavy hatch covers they are permanently rigged and the swivel lifting hook attached to the load chain is replaced by a suitable egg-shaped link capable of taking a Pattern 5458 shackle. The load chain is then permanently shackled to the lifting eyeplate on the hatch cover.

Before using a geared block having a double purchase whip always ensure that the chain forming the whip is not twisted by the action of the lower sheave having toppled over.

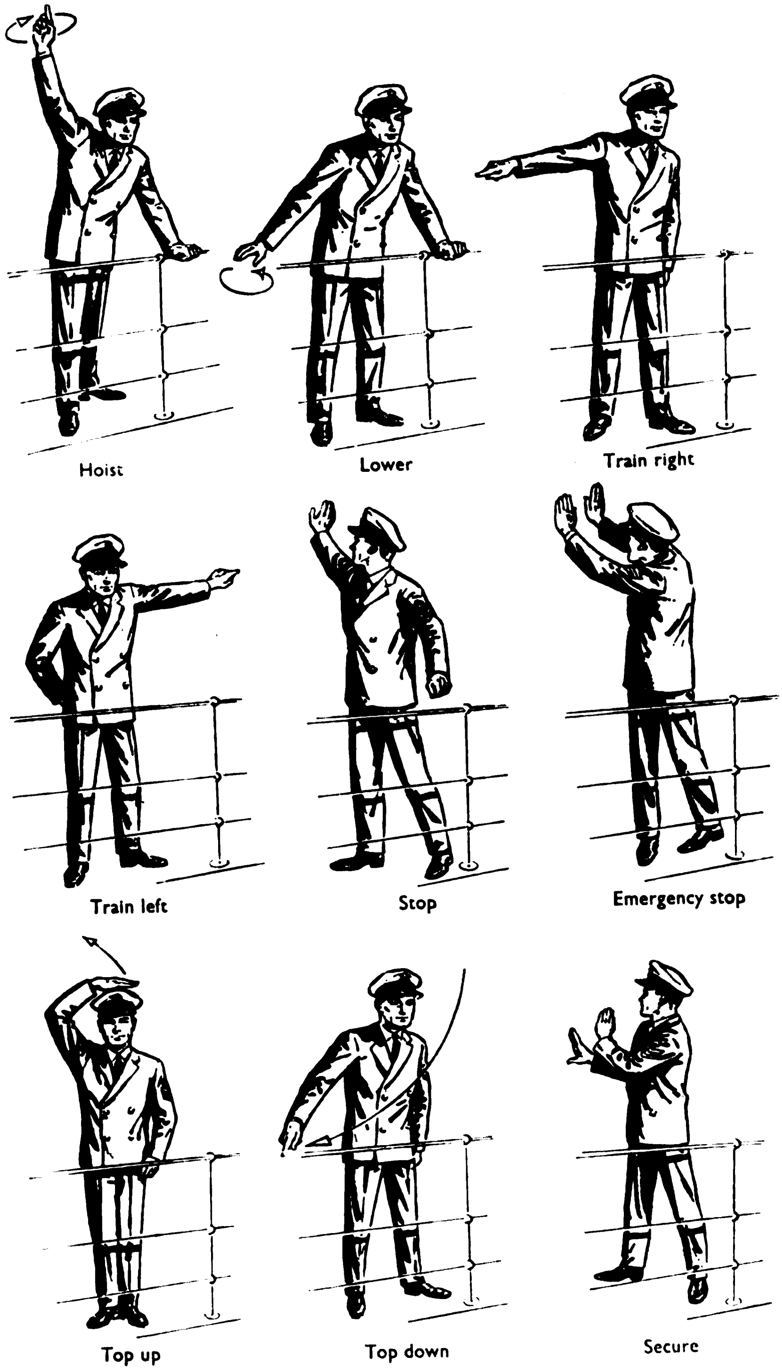


FIG. 6-7. Code of signals for working cranes or derricks

When a geared block is removed from one hatch to assist in the operation of another hatch, or for any other reason, the first hatch should be left shut.

SLINGING

When storing or ammunitioning ship, or when loading and unloading vehicles and general cargo, the correct sling must be used in the right way. In the Royal Navy a sling can be supplied in many forms, from a single length of cordage having a soft eye spliced in each end to a set of heavy-purpose slings constructed from chain or wire rope, capable of lifting motor transport and landing craft and having a safe working load of 30 tons or more. The choice of sling and the manner in which it is used depend upon whether one or a number of objects are to be slung in one hoist, the weight of these objects, and whether they are robust or fragile. If a number of objects are slung in one hoist the load is called a *set*. An introduction to slings and slinging is to be found in Volume I, and the general principles of slinging are illustrated here in figs. 6–8 and 6–9.

The main requirements are that the sling should be sufficiently strong to hold the load securely without crushing it, and the simpler the sling the easier it will be to handle it. The load must not spin and it must be as steady as possible at the start of the hoist. It is the duty of the slinger, be he a qualified dockyard slinger or an experienced member of the boatswain's party, to rig the sling or slings and hook it on, and to tend and steady the load until the crane or derrick has taken the full weight. In commercial ports and in naval dockyards the slinger is also responsible for giving the necessary orders to the winch-operator or crane-driver, who is seldom in a position to see all that is happening. These orders should never be by word of mouth, because verbal orders can easily be misinterpreted.

Hand signals for the control of ship's cranes and derricks (fig. 6–7). The Control Officer must stand where he can be seen by the crane-driver (or winch-operator), and he should wear red cuffs. If the crane-driver cannot see the control signals at any time, all movement of the crane must be stopped at once. At night the Control Officer must be sufficiently well illuminated for the driver to see his hand signals clearly.

Each movement of the crane should be stopped by the stop signal before another movement is ordered.

Cordage slings

Conforming to the British Standards Institution, cordage slings supplied to the Fleet (fig. 6–8) comprise the following:

single sling, used as a one-part or two-part lift, as shown in fig. 6–8(i) and (ii),

endless sling, used as a two-part or four-part lift, as shown in fig. 6–8(iii) and (iv),

two-legged sling (fig. 6–8(v)),

three-legged sling (fig. 6–8(vi)),

four-legged sling (fig. 6–8(vii)).

A single sling, commonly called a *snotter* and fitted with an eye at each end,

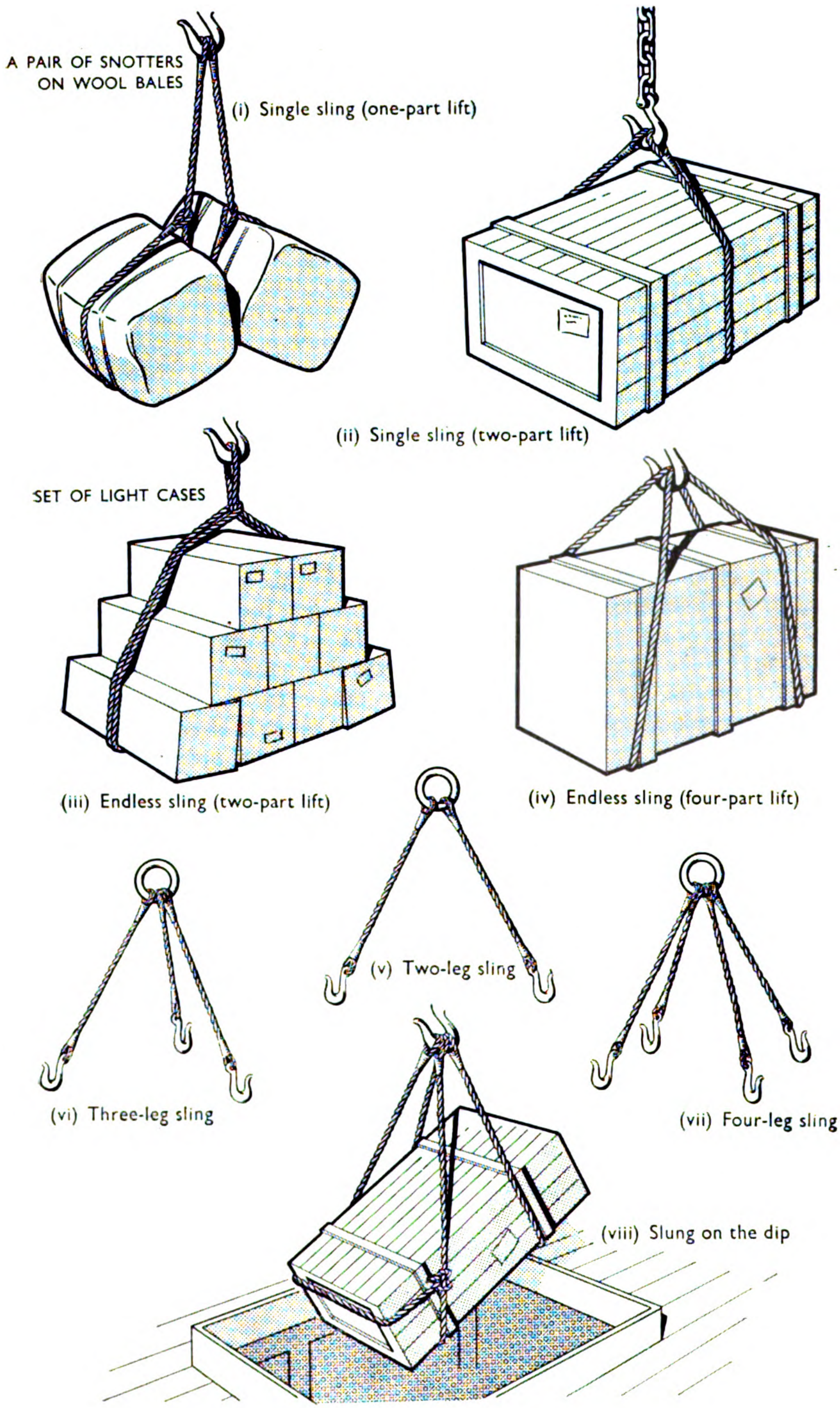


FIG. 6–8. Cordage slings

gives a good grip, is simple and quick to attach and convenient when dealing with large bales and carcases of meat, for example. It is better to use one sling for each item and to hoist four or five in one lift than to put all the items in one sling (fig. 6–8(i)).

An endless sling, commonly called a *bale sling strop*, can be passed either as shown in fig. 6–8(iii) (in which case if a heavy load is to be lifted not only will the load be subjected to a severe crushing effect, but the bight or the hook may slip as the hoisting gear takes the weight and tilt the load, perhaps dangerously) or, as shown in fig. 6–8(iv), by the more positive method in which a single heavy case is prevented from slipping by virtue of its weight and by the way in which both bights are placed over the lifting hook.

Legged slings, as illustrated in fig. 6–8(v), (vi) and (vii), are generally fitted to a ring, and their lower ends can either be fitted with hooks or have a thimble eye to take the crown of a shackle.

On the dip. If a load must be slung on the dip—in order to pass through a small hatch, for example—two single slings of different lengths should be used. To prevent the load from slipping one or more *cruppers* must be used (fig. 6–8(viii)).

NOTES

(i) *With any kind of load the splice of a sling must always be clear of both the lifting hook and the load.*

(ii) Cordage slings are easier to handle than wire slings and do less damage to paint and to packages, but they require careful watching for chafe and, when made of natural fibre cordage, rot.

(iii) When preparing to hoist heavy gear of some hard material, wooden packing pieces should be placed to protect the slings from sharp nips.

(iv) When a sling is passed through its own bight it cannot support as heavy a load as when each of its bights is placed over the lifting hook.

(v) Loads should be arranged so that the centre of gravity is as low as possible, and so that the angle between the parts of the sling is kept small; the problem of the angle between the parts of the sling is explained on page 176.

Wire rope slings

As with cordage slings, these (fig. 6–9) follow the same general pattern in design and should be used when heavier loads have to be lifted and cordage slings are unacceptable. Two- and three-legged slings are attached to one ring; but a four-legged sling, for heavier lifts, has two intermediate rings and a main lifting ring whose safe working load must be at least four times the safe working load of one leg of the sling.

Legged slings should generally be fitted with hooks at the end of each leg, but it is sometimes better to fit shackles—for example, when hoisting boom boats (as described in Volume I), landing craft or items which are fitted with specified lifting points designed to take the pin of a shackle.

Vehicle slings may comprise wheel nets with a four-legged wire or chain sling and spreaders, which hold the legs of the slings clear of the vehicle. In many cases wheel nets are being superseded by hub strops, which fit over an extension

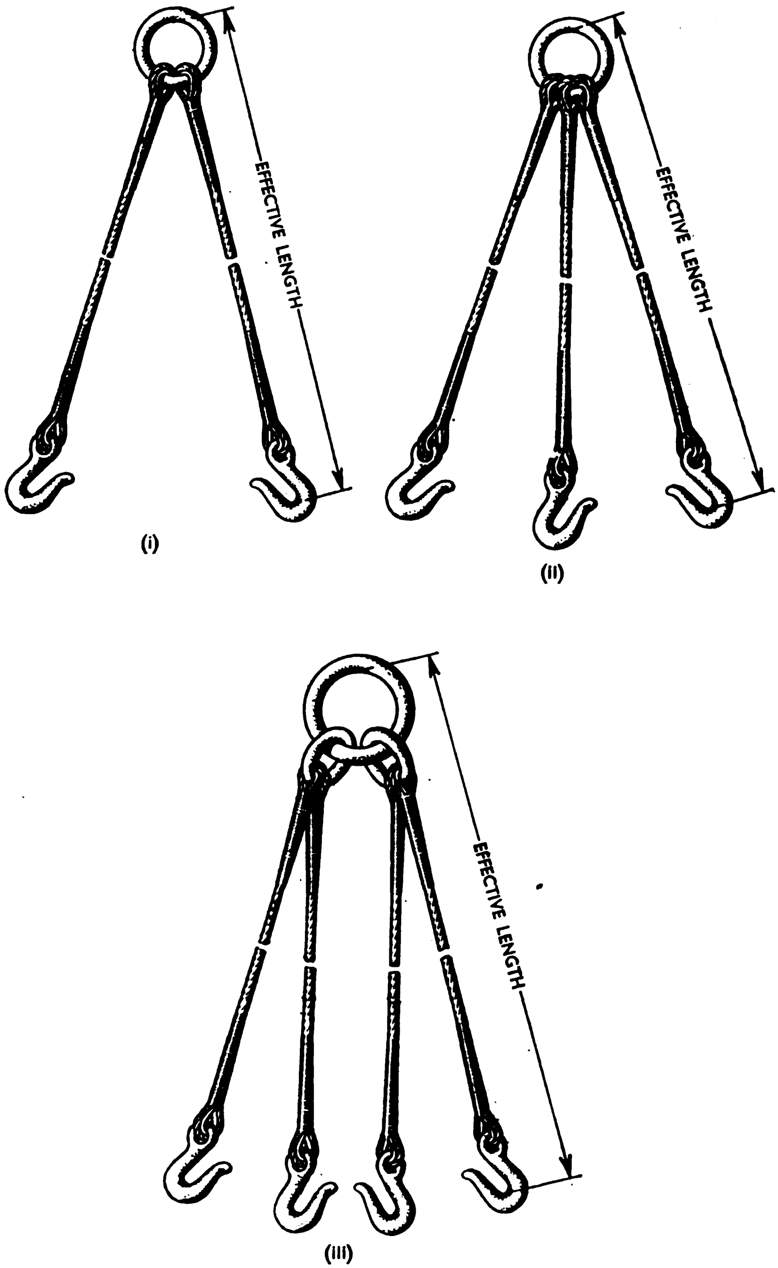
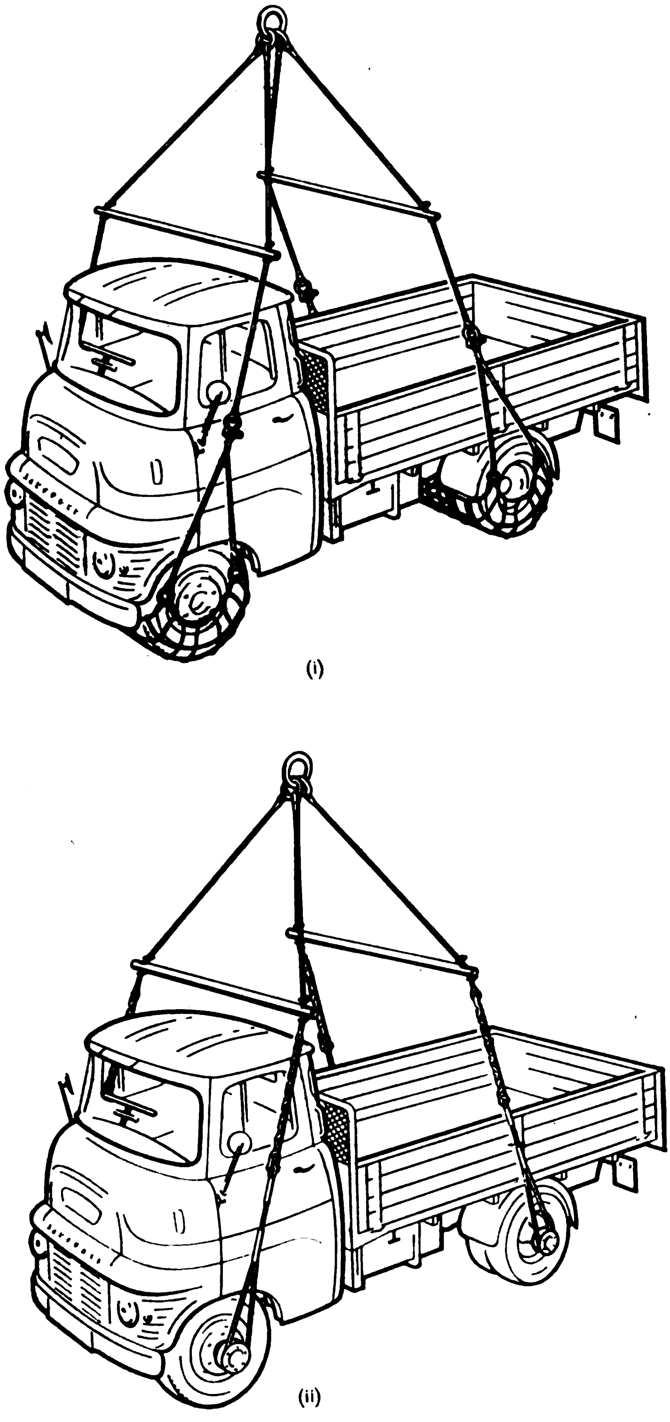


FIG. 6–9. Wire rope slings


(i)

(ii)

FIG. 6–10. Wheel nets and hub strops

of each wheel hub; but when there is any movement of the ship or of the craft containing the vehicle, hub strops must be tended until the crane or derrick has the full weight, and this may be extremely dangerous within a confined space. In such circumstances it is far safer to use wheel nets, which, if correctly placed beneath the wheels, will find their own centre of effort as the vehicle's weight is taken by the purchase.

Wheel net slings are widely used in the rapid loading and discharging of stores in aircraft carriers and commando ships. The vehicle is hoisted on board loaded, and either landed on the flight deck or struck down into the hangar. The advantage of this method of embarking large quantities of stores is obvious, a single hoist doing the work of several separate slingings from the jetty. For discharging stores the procedure is, of course, reversed.

The gear supplied for this method consists of two wire nets 8½ ft × 3 ft fitted with tested shackles, two wooden spreaders 9½ ft × 4 in. × 4 in. fitted with slotted ends and retaining bolts, four 3-in. F.S.W.R. single slings 20 ft in length fitted to intermediate rings and a main ring at the top and a thimble eye at the bottom, and eight bulldog grips.

The bulldog grips are secured to the single slings on each side of the spreaders to prevent them from slipping. The safe working load of a wire net is 3 tons, so that a total weight of 6 tons can be lifted safely.

The correct procedure for lifting is as follows:

1. Move the vehicle as near to the crane plumb as possible, and spread out the nets in front of each pair of wheels.
2. Move the vehicle on to the nets, making certain that the wheels rest centrally upon them.
3. Lower the four-legged sling about the vehicle and shackle each pair of legs to a net; leave the vehicle brakes off.
4. Take up the slack of the sling and nets and, with padding material, pack between the nets and the body where the nets may bear.
5. Lift the vehicle, taking care that the wheels are riding snugly in the nets.

Points to remember when using vehicle-lifting gear:

1. Spreaders must be used, otherwise much damage will be done.
2. See that the bulldog grips are firmly in position and place the pin through the end of the spreader.
3. When lowering a vehicle, lower the purchase slowly once the vehicle has touched, otherwise the spreaders may damage the vehicle or the stores.
4. It is often possible to leave the nets shackled to the slings, and to run the next vehicle on to them without dismantling the gear.

Miscellaneous cargo and slinging gear

The types of slings which have already been described are of a straightforward design; but to assist the seaman in handling stores more efficiently various items of equipment are available, and some of these are described below and illustrated in fig. 6–11.

The *canvas sling* (fig. 6–11(i)) is manufactured from cordage which encloses a rectangle of canvas measuring 2 ft × 10 ft 6 in. It has a long loop at one end

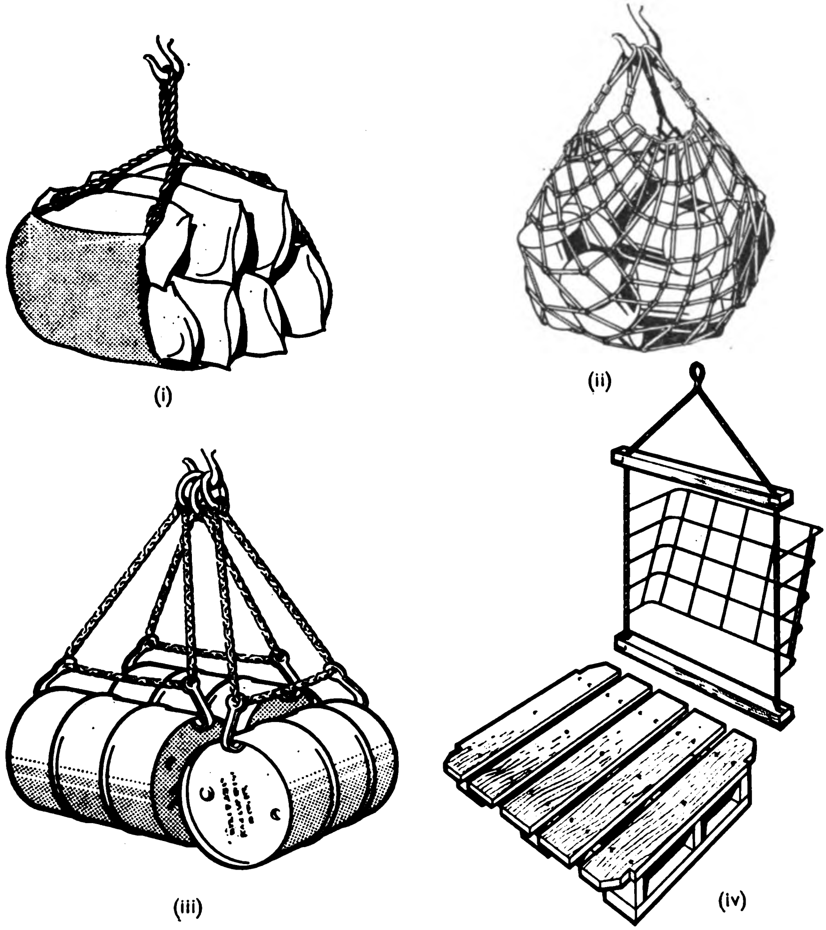


FIG. 6–11. Miscellaneous cargo and slinging gear

and a short loop at the other, and is used for lifting bags of flour or other similar stores, where an ordinary single sling would tear or burst the bags.

Cordage or wire provision net (fig. 6–11(ii))—the manufacture of which is described in Chapter 4—is used for lifting items of general stores which, when subjected to the bowsing-in moment, will not suffer damage. A circular net board of up to 6 ft in diameter can be placed inside the net when lifting fragile light cases and fruit boxes. A four-legged sling should always be used, in order to reduce the angle between the legs of the sling (not shown in illustration).

Can hooks (fig. 6–11(iii)) are used extensively in commercial practice for hoisting casks, drums and barrels; but in the Royal Navy they may be used only for breaking out bulk, after which the cask or barrel is slung by bale sling strop, butt sling or suitable container. Both these methods of slinging are described in Chapter 7 of Volume I.

Pallet and pallet sling (fig. 6–11(iv)). The pallet is a type of scaleboard of wooden construction approximately 5 ft × 5 ft which, when loaded with stores, can be lifted by a fork-lift truck, or can be hoisted by the pallet sling without first having to reeve the sling under the pallet before it is loaded. This arrangement is ideal for the transport of bulk stores of the same size. The pallets are filled at the storing depot, loaded on a lorry, trailer or lighter and taken to the ship, where they are hoisted inboard without the usual delay of separate slinging.

Conclusion

Only a few of the many kinds of slinging gear have been given here. The points to remember are many, but as long as the correct sling is used in the correct way for a particular load, safety will be maintained and personal satisfaction will be the reward for speed of handling.

Preparations for storing ship are described in Chapter 12.

SAFE WORKING LOADS OF SLINGS

Cordage slings

The safe working load of a cordage sling is one-eighth of the breaking strength of the rope, giving a factor of safety of 8. For example, the S.W.L. of a two-legged sling is the sum of one-eighth of the breaking strength of each part. This factor of safety takes into account such things as acceleration and deceleration, the unavoidable loss of strength where the rope is bent round a crane hook or other fitting, or where the rope parts are rove in bearing contact with one another at the crown radius of the bight, as in a single sling rove one-parted or an endless sling rove two-parted. Shock loading should be avoided, if possible; otherwise the factor of safety must be increased.

Endless slings used as a two-part lift (fig. 6–8(iii)) for all angles between the parts from 0 to 120 degrees have a safe working load calculated from the breaking strength of the two parallel parts. Different safe working loads will apply when the slings are used as a four-part lift (fig. 6–8(iv)).

In the case of fig. 6–8(i) and (iii) the loss of strength at the bight or eye, where it is in contact with the standing part, is as much as 50 per cent, because one part rubs against the other and there is a shearing action of the fibres on the bearing face of the bight or eye.

When using a single or an endless sling (fig. 6–8(i) and (iii)), it is inadvisable to beat down the eye or bight of the sling, for in doing so the angle between the two parts may be increased beyond the recommended safe angle of 90 degrees. When the angle between the two parts is 120 degrees there is a loss of working strength of 50 per cent, and 75 per cent for 150 degrees. It is only necessary to beat down the eye or bight sufficiently for the load to be effectively and safely bound and gripped; to continue beating down may increase the grip, but it will certainly reduce the working strength of the sling.

Two-, three- and four-legged sling safe working loads depend on a combination of the safe working load of one leg, the number of legs, and the angle between them. When a three-legged sling is used the safe working load of a

two-legged sling should apply, because one of the three legs may sometimes take approximately half the load. An advantage in having a third leg is that it exerts a steadying influence.

When a load must be slung on the dip, using cruppers (fig. 6–8(viii)), the legs of the sling connected to the lower end of the load support most of the weight. The combined safe working loads of the two lower legs must then be equal to the weight of the load.

Wire rope slings

The safe working load of wire rope slings is the same as for cordage slings, i.e. one-eighth of the breaking strength of the wire rope on each part or leg. When calculating the S.W.L. of a particular sling, the number of legs, the angle between them after the sling has been secured to the load, and the size of wire must be considered.

Slings supplied for use in the Royal Navy are fortunately, with a few exceptions, designed and made for one particular job—for example, boom boats, vehicles; their safe working loads have been calculated and stamped on the lifting rings or on metal collars round the wire. However, the seaman will often be required to handle general cargo and he will have at hand various slings with which he is expected to sling miscellaneous loads correctly and safely, or he may be required to improvise with the gear that happens to be available. He must then sling correctly with the right type of sling and not exceed its safe working load. These problems can be resolved by studying the illustrations in this section.

Notes on the use of slings

There is a direct relationship between the safe working load of a sling and the method in which it is used.

Great care should be taken to avoid kinks or sharp bends, as these can seriously reduce the strength of the wire rope when working under loaded conditions. When lifting a load having sharp corners, any acute bend can be eliminated by packing over the corners with wooden battens or other suitable material.

Errors in reeving slings should not be allowed to right themselves when the weight is taken; no doubt they will, but only at the expense of a shock load on the whole gear sometimes sufficiently serious to cause some part to fail. This is particularly important when the legs of a sling are shackled to the load; each leg should be tended to ensure that the shackle is not fouled and subjected to a shearing stress when the sling takes the weight.

When reeving a sling, the individual legs or parts should be loaded as uniformly as possible, and the included angle between any legs or parts should be about 90 degrees and never exceed 120 degrees.

Care must be taken, particularly with a long and heavy load, to ensure that the pick-up points are so spaced that when the load is being lifted it will be held in a steady and level position. If the pick-up points are too near to the centre line of the load, a see-saw action will result. Again, if the apex of the sling is not vertically above the centre of gravity of the load, the load will not be level

when lifted, and most of the load will be taken at first by the leg or legs at one end.

Cordage and wire rope provision nets are types of slings having safe working loads of 1·5 and 3 tons respectively. These safe working loads can only be applied when the load is spread between the corners of the net.

ESTIMATION OF STRESSES

Before describing cranes and derricks, etc. it is first necessary for the seaman to be able to calculate the stresses in the parts of the gear that he is using. Without this knowledge it is possible that a derrick, while hoisting an apparently safe load, will collapse; or that one of its fittings or a part of the rigging will fail, bringing work to a standstill and perhaps injuring people in the vicinity.

Triangle of forces

The stresses to which a derrick and its rigging or fittings may be subjected when supporting a load can be estimated approximately and very simply by the diagrammatic method known as the *triangle of forces*. The principles upon which this method is based can be stated as follows:

1. If the magnitude and direction of a force are known it can be represented by a straight line, called a *vector*, the length of which indicates its magnitude and the direction of which, denoted by an arrow, gives the direction in which the force acts.
2. If three forces acting at a point are in equilibrium, and the vectors representing them are drawn end to end so that the directions in which they act are maintained—i.e. so that the arrows follow one another—they will form the three sides of a triangle.
3. If three forces acting at a point are in equilibrium and the magnitude and direction of only two of them are known, the magnitude and direction of the unknown force can be found as follows: Draw the vectors of the known forces end to end so that the arrows follow one another. Complete the triangle. The third side will then represent the unknown force in magnitude and direction, the arrow pointing from the head of the second vector to the foot of the first.
4. When three forces acting at a point are in equilibrium, if the magnitude and direction of one force and the direction only of the other two are known, the magnitude of these two unknown forces can also be found by drawing a triangle of forces.

For three forces in equilibrium, the arrows denoting the directions of the vectors always follow one another round a triangle of forces. If more than three forces in equilibrium and acting at a point are involved, the same principles apply. The resulting figure, whose sides represent these forces, is then known as a *polygon of forces*. The following two examples show the application of this method for finding the approximate stresses in masts, derricks and their rigging and fittings. In the examples it is assumed that the systems and their loads are at

rest, and the effects of any friction are disregarded.

EXAMPLE 1 (fig. 6–12). A derrick is topped at an angle of 45 degrees with the horizontal and is supporting a weight of 5 tons hung on the end of its whip. Find the magnitude and direction of the tension in the strop of the head block.

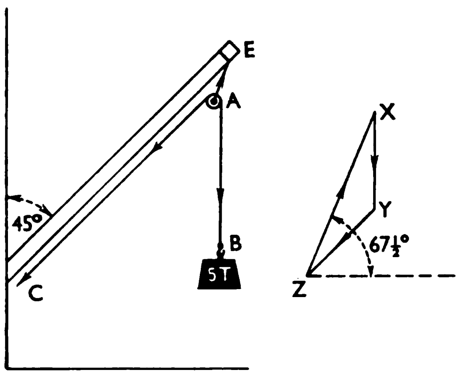


FIG. 6–12. Estimation of stresses by triangle of forces (1)

The tensions in the running and hauling parts of the whip are the same, namely 5 tons, so by drawing a triangle of forces based on the block *A* the tension in the strop *AE* and the direction in which it acts can be found in the following manner: To a scale of one inch to 10 tons draw the vector *XY*, $\frac{1}{2}$ in. in length, to represent the vertical downward pull of the weight on the running part of the whip, and on it mark its arrow pointing downwards. From the point *Y* draw another vector *YZ*, parallel with *AC* and $\frac{1}{2}$ in. in length, to represent the downward tension in the hauling part of the whip, and on it mark its arrow, also pointing in a downward direction. Complete the triangle by joining *Z* to *X*. Then:

ZX is the vector representing the tension, both in magnitude and direction, in the strop *AE* of the head block, and when measured it will be found to be approximately 0·95 in., representing a tension of $9\frac{1}{2}$ tons acting upwards at an angle of $67\frac{1}{2}$ degrees with the horizontal.

EXAMPLE 2 (fig. 6–13). A span is rigged between two masts and a weight of 10 tons is hung on it so that the left leg of the span makes an angle of 45 degrees with its mast and the right leg of the span makes an angle of 65 degrees with its mast. Find the pull on each of the shackles which join the span to the masts.

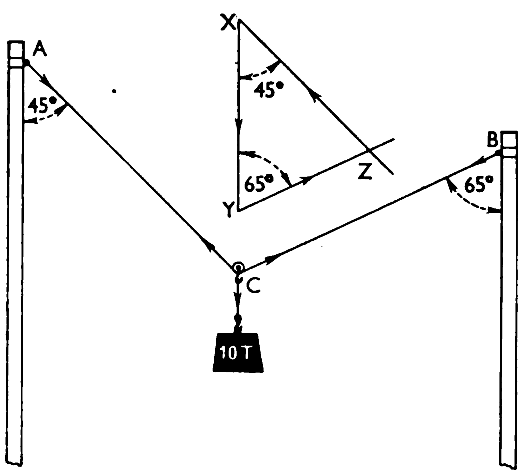


FIG. 6–13. Estimation of stresses by triangle of forces (2)

The pull on the shackles will be equal and opposite to the tensions in the respective legs of the span, and these tensions are found by considering the forces acting at the point *C*, where the magnitude and direction of the pull of the weight on the span are known, i.e. 10 tons vertically downwards, and the directions of the tensions in the legs of the span are

known, i.e. upwards at angles of 45 degrees and 65 degrees respectively with the perpendicular.

To a scale of one inch to 10 tons draw the vector XY, 1 in. in length, to represent the vertical downward pull of the weight, and on it mark its arrow, pointing downwards. From the point Y draw a line parallel with CB and on it mark an arrow to represent the direction of the upward tension in the right leg of the span. From the point X draw a line parallel with AC so that it cuts the preceding line at Z, and on it mark an arrow to represent the direction of the upward tension in the left leg of the span. Then:

YZ is the vector representing the tension in the right leg of the span, which will be found to be 0·75 in. long (approximately), representing a force of 7½ tons; and

ZX is the vector representing the tension in the left leg of the span, which will be found to be 1 in. long (approximately), representing a force of 10 tons.

The approximate pulls on the shackles at A and B will therefore be 10 tons and 7½ tons respectively.

In a similar manner the stresses on other parts or fittings of a mast and a derrick, such as the tension in the topping lift and the thrust in the derrick, can be found if the magnitude and direction of two of the three forces involved are known, or if the magnitude and direction of one force and the direction of the other two forces are known. Care should be taken when determining the direction in which a force acts; for example, when considering the stresses at the derrick head the tension in the topping lift of a derrick will be acting in a direction from the head of the derrick towards the mast, but when considering the stresses at the masthead fitting it will be acting in the reverse direction.

Reduction of stresses

The stresses on certain parts or fittings of a derrick can be considerably reduced by altering the rig. This is sometimes necessary if the derrick is to be used to hoist more than its safe working load, or when a fitting has to be replaced by one lacking the required strength. By fitting a double whip, or a purchase instead of a single whip, or by leading the whip to the masthead, the loads on the various parts of the derrick can be considerably reduced. This is shown in the following three examples in each of which the derrick is 25 ft long, the topping lift is 20 ft above the heel of the derrick, the span of the topping lift is 18 ft, and the weight supported by the derrick is 10 tons. The *triangle of forces* method has been employed to show the manner of its use, and the weight of the derrick and its fittings and the effect of friction have been disregarded. The scale of the diagrams is only very approximate.

1. *Single whip* (fig. 6–14). The load on the head block shackle AF is found by drawing the triangle GHJ, in which GH (parallel with AE) equals HJ (parallel with AD), each equal to 10 tons, and JG represents the magnitude and direction of the pull AF, equivalent to 17½ tons.

The tension in the topping lift BC and the thrust in the derrick BK are found by drawing the triangle LMN, in which ML is equal to and parallel with JG, LN is parallel with BC, and MN is parallel with BK. LN represents the tension in the topping lift, equivalent to 9 tons, and NM represents the thrust

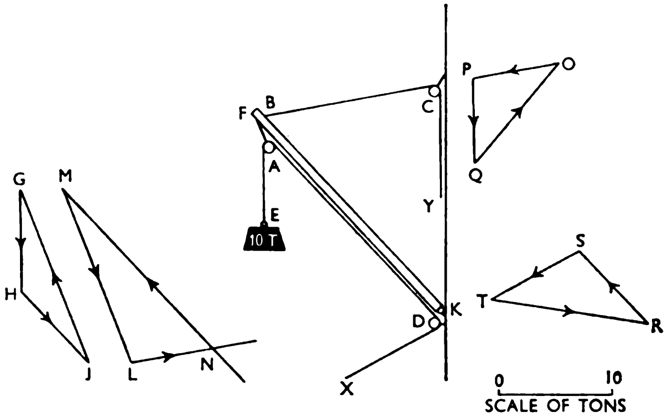


FIG. 6–14. Stresses in a single whip

in the derrick, equivalent to 22½ tons.

The load on the topping lift leading block *C* is found by drawing the triangle *OPQ*, in which *OP* (parallel with *LN*) equals *PQ* (parallel with *CY*), each equal to 9 tons, and *QO* represents the magnitude and direction of the load on the block shackle, equivalent to 13¾ tons.

The load on the whip leading block *D* is found by drawing the triangle *RST*, in which *RS* (parallel with *AD*) equals *ST* (parallel with *DX*), each equal to 10 tons, and *TR* represents the magnitude and direction of the load on the block shackle equivalent to 15 tons.

2. *Double whip* (fig. 6–15). The various triangles are drawn in a similar manner to that for the single whip, and from them the following forces are found:

load on head block *JG*, equivalent to 14 tons;
tension in topping lift *LN*, equivalent to 9 tons;

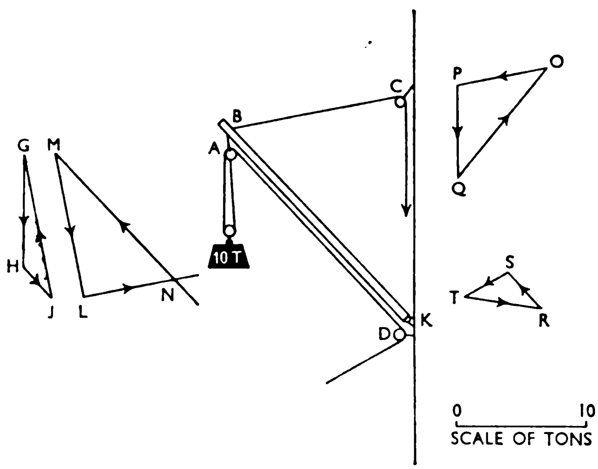


FIG. 6–15. Stresses in a double whip

thrust in derrick *NM*, equivalent to 17½ tons;
load on topping lift leading block *QO*, equivalent to 13¾ tons;
load on whip leading block *TR*, equivalent to 7½ tons.

3. *Double whip led through masthead leading block* (fig. 6–16). The various triangles are drawn in a similar manner to that for the single and double whips, and from them the following forces are found:

load on head block *JG*, equivalent to 10½ tons;
tension in topping lift *LN*, equivalent to 3¾ tons;
thrust in derrick *NM*, equivalent to 12½ tons;
load on topping lift leading block *QO*, equivalent to 6 tons;
load on lower whip leading block *TR*, equivalent to 4½ tons;
load on upper whip leading block *ZX*, equivalent to 8 tons.

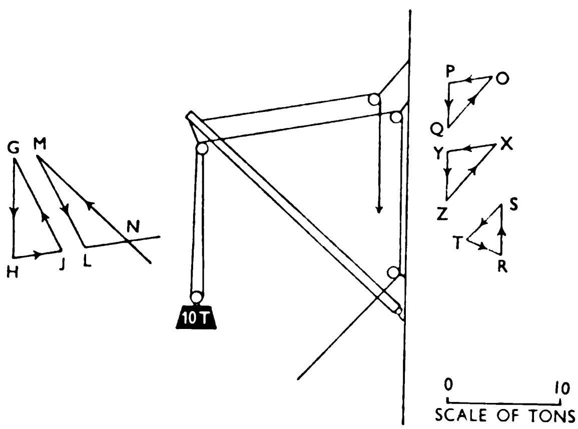


FIG. 6–16. Stresses in a double-whip rig led to the masthead

The forces involved in the three types of rig illustrated in the three examples can be compared in the following tabular statement, which clearly shows the advantages to be gained by modifying the rig.

	Single whip	Double whip	Double whip with hauling part led aloft
	tons	*tons*	*tons*
Load on head block	17½	14	10½
Tension in topping lift	9	9	3¾
Load on lower whip leading block ..	15	7½	4½
Load on topping lift leading block ..	13¾	13¾	6
Load on upper whip leading block ..	—	—	8
Thrust in derrick	22½	17½	12½

Lead of topping lift and angle of derrick

The *lead of the topping lift* is important. Fig. 6–17(i) shows a 30-ft derrick with a 20-ft standing topping lift led to a point on the mast 20 ft above the heel

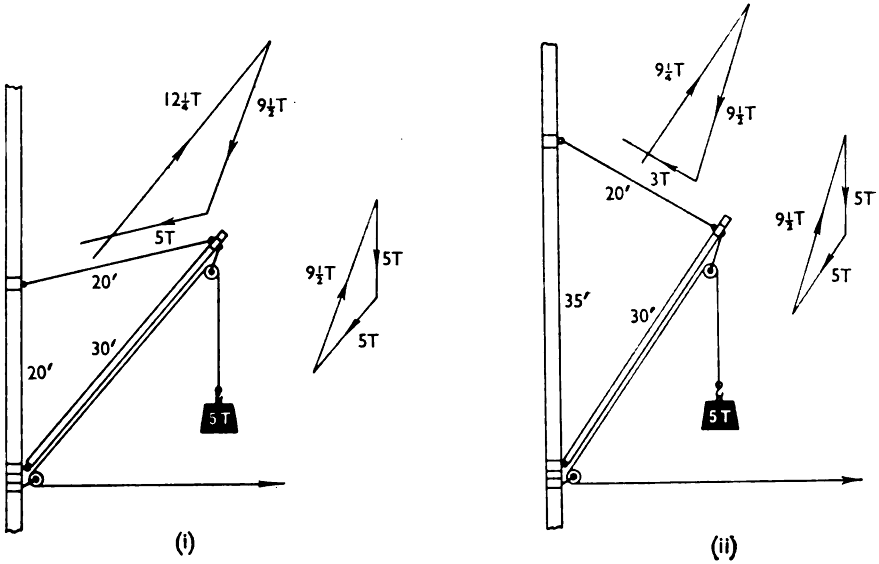


FIG. 6–17. Lead of topping lift

of the derrick. When supporting a weight of 5 tons the tension in the topping lift is 5 tons and the thrust in the derrick is 12¼ tons. When the topping lift is led to a point 35 ft above the heel (fig. 6–17(ii)) the tension in the topping lift is reduced to 3 tons, and the thrust in the derrick is reduced to 9¼ tons.

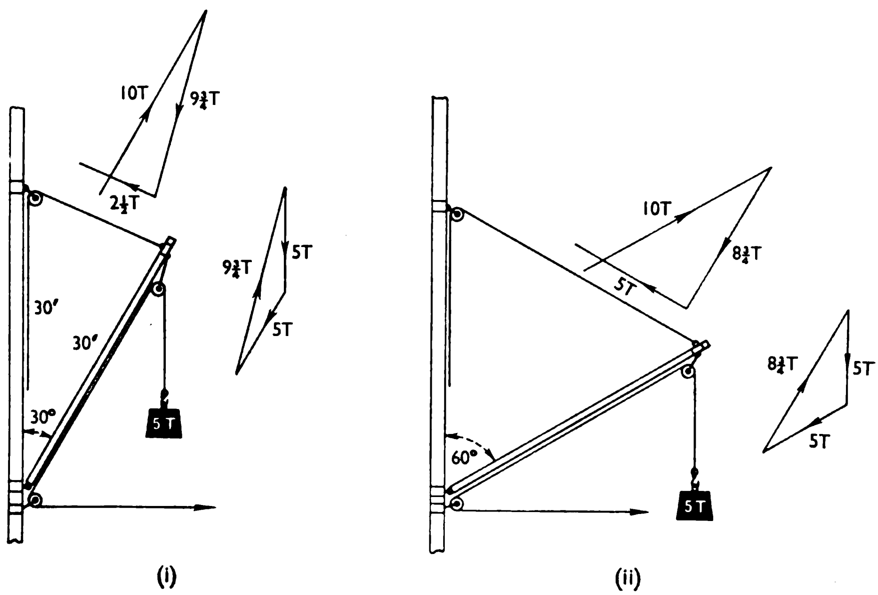


FIG. 6–18. Angle of derrick

The *angle at which the derrick is topped* also has a bearing on the tension in the topping lift, but not on the thrust in the derrick. Fig. 6–18(i) shows a 30-ft derrick topped at an angle of 30 degrees with the mast by a working topping lift led to a point on the mast 30 ft above the heel of the derrick. When supporting a weight of 5 tons the tension in the topping lift is 2½ tons, and the thrust in the derrick is 10 tons. When the derrick is lowered to an angle of 60 degrees with the mast the thrust in the derrick remains the same, but the tension in the topping lift is increased to 5 tons (fig. 6-18(ii)).

DERRICKS, WINCHES AND CRANES

In the Royal Navy all the items of equipment described in this section are provided for a variety of purposes, such as hoisting boom boats, storing and ammunitioning ship and replenishment at sea. Merchant Navy equipment is basically similar; and because it is used for handling great quantities of general cargo, the first part of this section will deal more with the commercial than the Fleet application. Nevertheless, the working of derricks, winches and cranes, and their component rigging fittings, are usually common to both Services and differ only in individual items and designs. A brief description of derricks and winches is given in Volume I, and information on merchant ships and cargo stowage in Volume III.

It is the seaman's responsibility to know how to work his own ship's gear safely and efficiently, and also how to work commercial gear; then he will be able to assist in working a merchant ship should the need arise.

This section is a development of Slinging (page 169), which subject cannot be separated from the derrick or crane which hoists the load.

DERRICKS

Derricks vary considerably in their type, rig and the manner in which they are worked. Some typical Merchant Navy derricks are described below, together with some of the ways in which they are worked.

Rigs of derricks

It is customary to provide one winch for each derrick, the whip or *runner*, as it is often called, being led to the winch drum and the guys and working topping lift (if fitted) taken as required to the warping drums. The topping lift is usually adjusted to the angle at which the derrick is required to work and is then stoppered by a *snotter*. The snotter is usually a length of long-linked rigging chain, shackled to a union plate fitted in the topping lift fall, with the appropriate link in the other end shackled to an eyeplate on deck (fig. 6–19(ii)).

The positions of the topping lift and whip leading blocks are important. The topping lift upper leading block must be situated directly above the heel of the derrick (fig. 6–20(i)), otherwise the derrick will either cock up or droop when it is guyed off the centre-line (fig. 6–20(ii) and (iii)); with heavy derricks this block may be a trunnion block, hinged vertically to the mast so that it pivots in line with the derrick. The lower leading blocks should be close under the heel

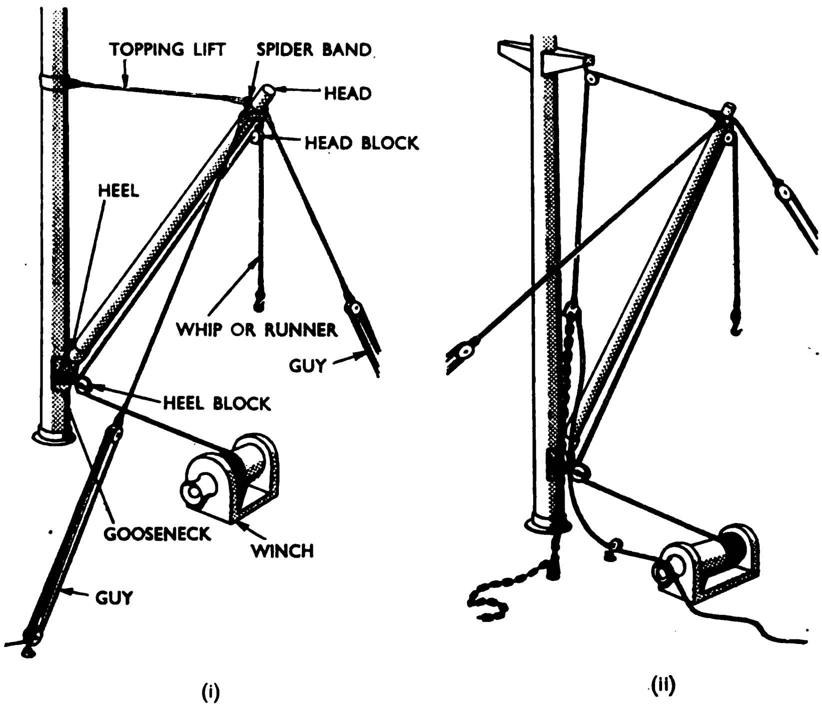


FIG. 6–19. Rigs of mast derricks

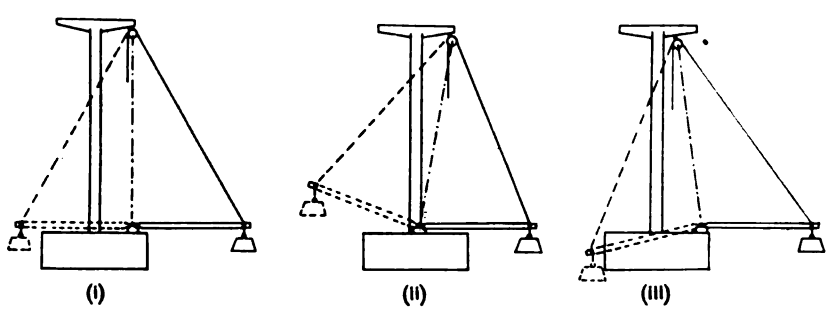


FIG. 6–20. Correct and incorrect leads of a topping lift

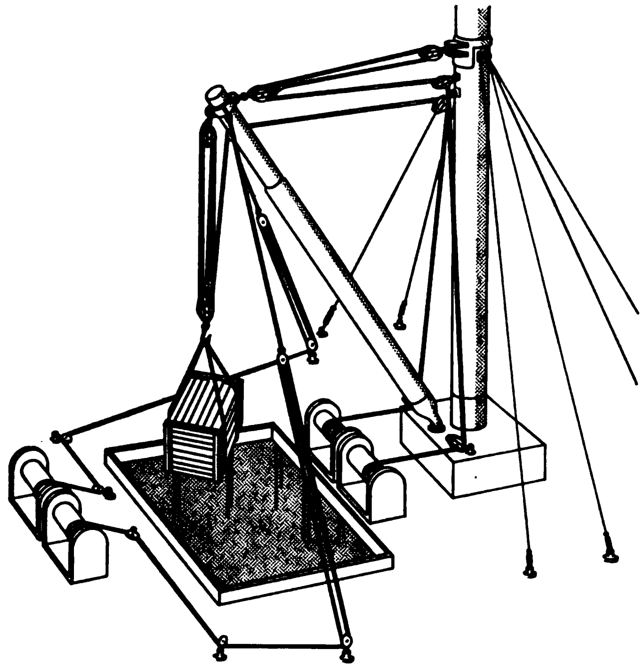


FIG. 6–21. Heavy lift derrick

of the derrick and should also give a straight lead for the falls to the winch drum or warping drum; the whip lower leading block is triced up, or designed to stay upright, when the whip is slackened.

The derricks normally used for working general cargo have safe working loads of between 3 and 12 tons. Heavy derricks with safe working loads of 10 tons or more can be rigged in many ways, one of which is illustrated in fig. 6–21; the whip is replaced by a *purchase* with its fall led through an upper leading block on the mast so that it assists the topping lift, and the guys are brought to winches or warping drums.

Many ships are equipped with one, and sometimes two, heavy-lift or *jumbo* derricks; the maximum load these can lift varies from 30 tons to as much as 180 tons. They are provided with special ballasting arrangements to ensure that they have the necessary margin of stability when hoisting heavy loads out or in. Such derricks are stowed vertically, and clamped or locked in that position.

Working of derricks

There are many methods of working derricks, usually depending on the type and weight of cargo to be handled; three such methods are described below.

Union purchase method (fig. 6–22). A common method of working cargo with hoists of up to 1·5 tons is the union purchase, or yard and stay method, in which two derricks are rigged so that one will plumb the hold while the other is turned out over the ship's side to plumb a lighter or the loading wharf. Their whips

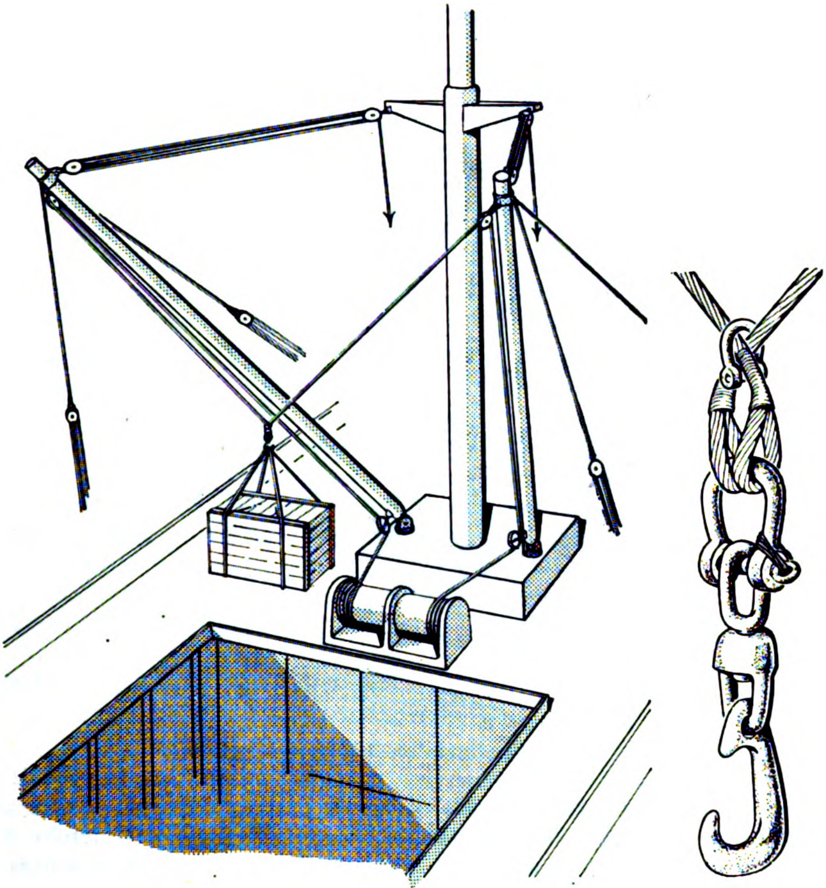


FIG. 6–22. Union purchase method

are joined together by a union hook, or by the method shown in the inset of fig. 6–22, either of which prevents the joining shackle being unduly stressed when the whips pull in opposite directions. The load is first hoisted by one derrick while the slack in the whip of the other is taken down; when the load is clear of the hatchway or bulwarks it is then transferred to the other derrick and lowered into the lighter or on to the wharf, as the case may be. To avoid undue stress the angle between the two whips must be kept as small as possible; the longer the derricks the smaller this angle will be. Auxiliary guys should always be rigged if there will be any heavy sideways pull on the derricks.

Deadman or backweight (fig 6–23). Another quick method of working light cargo is to use a swinging derrick, the inboard guy of which is led through a block at the head of a stationary derrick at the opposite side of the hatch. To this guy, at a suitable height, is hung a weight known as a *deadman* or *backweight*, and the outboard guy is rove as a runner, the hauling part of which is brought to a winch and hauls the derrick against the weight of the deadman. When the winch is reversed the weight of the deadman hauls the derrick back into position.

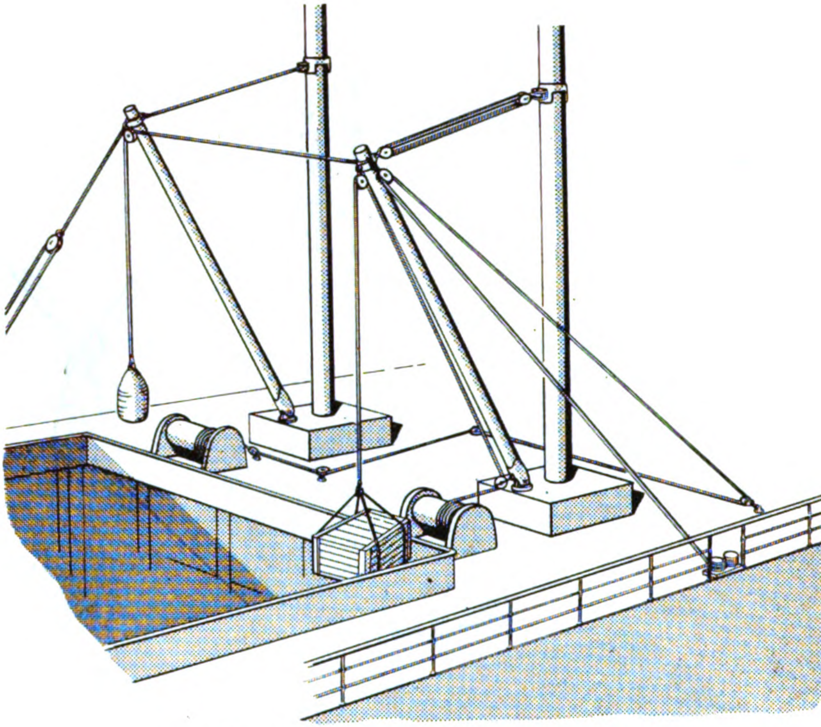


FIG. 6–23. 'Deadman' or 'backweight' method

Heavy lifts (fig. 6–21). For loads of over 1·5 tons a swinging derrick and greater care in working are necessary. The derrick must be carefully and adequately guyed so that it will be under complete control at all stages of hoisting and lowering; to be effective the guys must be led at a broad angle with the derrick and as nearly horizontally as is practicable. If the load is particularly heavy additional auxiliary stays must be fitted to the mast or sampson post to enable it to withstand the heavy stresses involved. If the load is heavy enough to list the ship when the derrick is swung outboard it may be necessary to keep her upright by ballasting, not only to preserve the ship's stability, but also to prevent any tendency for the derrick to take charge if the upper leading block of the topping lift no longer plumbs the heel of the derrick. If a loaded derrick does take charge and starts to swing outboard, much damage can be prevented to the derrick, stays and other fittings by the prompt lowering of the purchase as the load clears the ship's side; for in lowering the purchase roundly a great deal of stress is removed from important points in the system.

Heavy loads should be kept under control at all times by steadying lines led from each corner to winches or tended by hand. If a load gets out of control when there is movement on the ship, the load will probably double the distance of its swing with each athwartship arc of travel. The swing must be stopped immediately by hoisting up the purchase until nearly two blocks, thereby reducing the length of the effective pendulum, or, if the load is not hoisted too far above the deck, by lowering it roundly to the deck, always bearing in mind

that the deck must be strong enough to withstand the impact.

Precautions when working derricks

Preventers in the form of standing topping lifts and guys may be fitted to derricks to confine their movements in the vertical and horizontal planes within those arcs in which the derrick is designed to carry its safe working load. Such derricks should not be worked outside these safe arcs unless special precautions are taken to strengthen the mast and derrick. A mast or a derrick can be strengthened by binding stout battens or staves tightly round its centre portion over about two-thirds of its total length (see 'Fishing a spar', on page 216). A mast can be strengthened against buckling stresses by fitting it with extra stays; masts carrying jumbo derricks are either specially strengthened or provided with such stays, and they must always be fitted and set up before the jumbo derrick is used.

A derrick should never be worked at an angle below the horizontal.

When a derrick, or any other similar equipment, is used to hoist a boat the lifting weight of the boat shown on pages 293 and 295 does not include bilge water or any extra equipment or fittings. When the specified weight of the boat is nearly equal to the safe working load of the derrick these factors must be taken into account in order to ensure that the safe working load at the specified radius is not exceeded.

Testing derricks and hoisting gear

The testing of derricks in the Royal Navy is regulated by Navy Department orders, and instructions are contained in Appendix 3 of B.R. 2203, *Ship Husbandry Manual*. In the Merchant Navy such tests are regulated by the Docks Regulations or the Factory and Workshops Act. An outline of Navy Department regulations is given below, but when detailed information is required the relevant orders must always be read.

All hoisting systems are tested as a unit before being brought into service, and subsequently at each refit and after repair or removal while in service. The period between tests must never exceed 2½ years. Associated spare gear is tested separately at the same time as the main system.

The tests during manufacture of wire rope made to Navy Department specification are sufficient to guarantee its strength, and further samples are not tested before a rope used for hoisting is brought into service.

All wire rope associated with a lifting appliance has a safe working load of one-eighth of its specified breaking strength, i.e. a factor of safety of 8. Rope that has been used for hoisting, and is not otherwise tested as part of a lifting system, is subjected at intervals not exceeding 2½ years to a dead load test of two-fifths of its specified breaking strength.

Procedure for testing. The term 'safe working load' used in connection with these tests is the maximum weight which the system, when properly rigged, is approved to hoist; and will usually be less than the safe working load stamped on some of the component parts, such as leading blocks and shackles.

The derrick as a whole system should first be surveyed, then the tests described below are carried out by dockyard officers in the following order:

1. The derrick is loaded at rest with a static load equal to twice the safe working load. If the purchase is of cordage this static load is not suspended by the purchase, but is hung by a strop on the head of the derrick to avoid overstretching and injuring the cordage.
2. The derrick is loaded with its safe working load and raised and lowered and slewed so as to test all parts of the system; this load is moved to the fullest extent possible throughout its complete designed range.
3. The derrick is loaded with a running load of one and a half times the safe working load and moved in the same manner as described in paragraph 2.

After each of the three tests the whole of the gear is carefully examined visually for flaws and defects and repaired and retested if necessary.

Markings on derricks and hoisting gear. In the Royal Navy a *test tally plate* is fixed on or near each hoisting system and marked with the following information:

a statement that the system was tested with the approved rig,

the place and date of test,

the static test load,

the running test load,

the safe working load,

the initials of the person responsible for the test.

Never forget that the safe working load shown on a test tally plate is that of the complete system and not that of any individual part or fitting.

WINCHES

A general description of winches is given in Volume I; here it is intended only to explain how general-purpose winches function.

In the Royal Navy winches are used for cargo-handling, minesweeping, boat-hoisting, handling torpedoes, ammunitioning, for example, and are usually electrically driven. In the Merchant Navy winches are used mainly for cargo-handling. They must be efficient, because the length of time during which the ship is not working, i.e. not at sea, depends on the speed of turnaround. In both Services the winch driver must be a man of considerable experience; for not only will a high standard of safety be maintained only through continuity and experience, but the speed of any evolution will be greatly increased by competent and smooth handling of the winch. An inexperienced winch driver can damage the gear which he controls; a wrong movement can easily cause gear to fail, with resulting injury to personnel.

General-purpose winches (fig. 6–24)

A winch, which may be driven by steam or by electric or hydraulic power, is used for hauling ropes, hawsers and running rigging. Cargo winches for working the running rigging and whip of a derrick have warping drums on each end of the main shaft; these drums can be worked independently of the main drum. (How to bring a rope to a warping drum is described in Vol. I, page 230.)

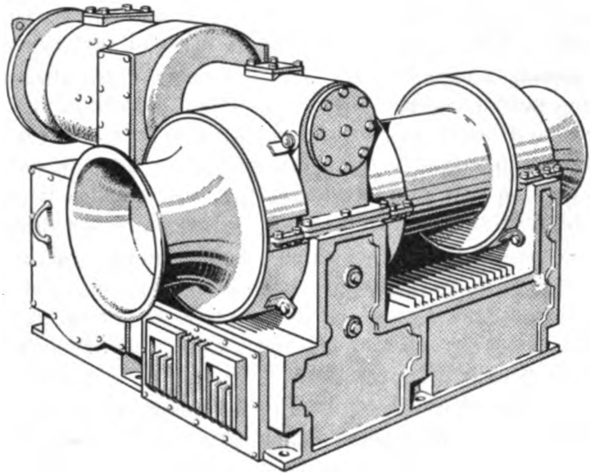


FIG. 6–24. Typical electric cargo winch

Steam winches, controlled by throttle and reversing lever, vary considerably, particularly in the method of lowering the load, and great care is needed when first driving them. One type, designed for quick lowering, has a friction clutch between the engine and the drum. When lowering, the clutch is disengaged and the load descends by its own weight, controlled by the brake. A steam winch will 'walk back' if steam pressure fails, unless the hand brake is applied.

An electric winch is operated by means of a controlling switch and a mechanical brake, which may be either foot- or hand-operated. The brake is used to slow down the winch, but not to stop it, as this would damage the electrical mechanism. A powerful automatic brake is also fitted for preventing any movement of the winch when there is no current flowing through the motor, as may occur if the controlling switch is broken or if there is a power failure. For quick lowering, the automatic brake of some electric winches can be held off mechanically when the controlling switch is broken; the load then lowers itself by its own weight, the speed of lowering being controlled—and the winch stopped when required—by the brake.

Some power-driven winches are fitted with two gears, the double (or lower) gear being used for heavy loads.

Basic precautions

Winch drivers and warping drum operators must be experienced. A few basic precautions are given here to ensure safety. Precautions to be taken when surging are given in Vol. I, page 231.

1. The winch driver must always be able to see the hand signals of the person in charge. If any signal is not understood no action should be taken unless the winch is moving; in that case it must be stopped.
2. Never attempt to drive a winch and handle a rope on the warping drum at the same time. This practice has led to many serious accidents in the past.

3. To start a hoist from rest at any speed other than slowly will cause shock loading which, if in excess of the safe working load, may cause an accident.
4. When manning a rope leading from a warping drum always ensure that the hauling part leads from the top or open end of the drum. This will provide visual proof that each turn on the drum is free. A rope which leads from the bottom may develop a riding turn, which will not be apparent until the hauling part is jammed and starts to be pulled back through the hands. The rope may then slip out of control round the drum.
5. If a riding turn develops the winch must be stopped at once, and then operated slowly in the opposite direction until the turns are free. An incorrect lead to the warping drum is often the cause of a riding turn developing, and it should be noted that a correct lead is one that is leading very slightly away from the centre of the drum.
6. Never stand close to a warping drum when manning a rope. Stand so that when the arms are fully extended they clear the after side of the drum by at least one arm's length, further if the rope is Nylon or Terylene. Should the rope then render, you will have room to check the surge and not be seriously injured by being caught by the hands and dragged round the drum.
7. Never stand in the bight of a rope which is on deck abaft the warping drum. It is a relatively simple operation to coil down the rope by giving it a flick as it comes off the drum.
8. Never stand in the line of a man-made fibre rope under tension.

Tests of winches

Winches are tested by dockyard officers at each ship refit, and the period between tests must never exceed 2½ years. Various tests are carried out, depending upon the particular task for which the winch is designed and employed. These tests concern the technical branches, and it is sufficient to mention here that every winch is tested as a part of some complete system.

CRANES

Cranes supplied for ship-borne use are quicker and more convenient in operation than derricks, but, weight for weight, they are not nearly so strong. Their characteristic feature is a jib, or projecting hinged arm, the head of which can be raised or lowered by a wire rope topping lift rove as a tackle. Cranes are either fixed or mobile, and are used to hoist boats, aircraft, stores, ammunition, for example. Fixed cranes are fitted in cruisers and above, and mobile cranes are carried in aircraft carriers and commando ships.

There are many types of crane used in the Royal Navy. One type, which will be found in general use, is described below.

General-purpose fixed crane

The purchase of wire rope is rigged as a single whip and leads from the purchase winding drum to a sheave at the head of the jib. Between the purchase wire and the lifting hook is a weight called the *ponder ball*, the function of which

is to assist the purchase to overhaul when there is no load on the hook; in some cranes the ponder ball is made in two halves for ease of removal, and some incorporate a shock-absorbing device. Besides hoisting and topping, a crane can be trained to plumb a hoist, the arc of training being restricted by an automatic electric cut-out to prevent damage to the crane and superstructure.

The safe working load and maximum radius permitted are usually engraved on the maker's nameplate, and cranes supplied to H.M. ships are designed to train with their full safe working load with the ship listed to, but no more than, five degrees; these limits must not be exceeded in practice. A safe-loading indicator and an electrically-operated bell are fitted to give warning should the specified safe working load of the crane be reached or exceeded; in addition, overload trips are fitted in the electrical system, but these may not operate until the overload is considerable. The structure of the crane is designed to be stronger than its lifting ropes, except, of course, when subjected to any undue sideways pull. Once the crane has been overloaded the wire lifting ropes must be inspected.

Purchase and topping lift. The upkeep of a crane is chiefly the responsibility of the ship's electrical department, but the seaman is responsible for the care and maintenance of the purchase and topping lift ropes. These two wire ropes are of different construction, length and size and are not interchangeable; they differ also in cranes of different type. A spare topping lift and purchase are carried for each crane in the ship. The purchase rope is a non-rotating wire specially constructed to prevent it from spinning when hoisting a load. It consists of twelve outer strands of right-handed Lang's lay laid up round three oval inner strands of left-handed Lang's lay on a hemp heart; the outer strands have six wires each and the inner ones twenty-four. The outer end of the purchase rope is fitted with a socket to which the ponder ball and lifting hook are secured; the inner end is fitted with a socket or solid thimble to fit the anchorage bolt on the winding drum.

In most cranes the topping lift consists of two twin ropes, each of 6 × 37 construction Lang's lay; they are usually fitted at both ends with solid thimbles to secure them to the topping lift winding drum and to their appropriate block beckets. Both topping lift wires should be renewed at the same time; otherwise they will not share the load evenly, because the older wire will have stretched to a greater length than the new one.

Maintenance consists chiefly in a periodical examination, as laid down for wire ropes in the relevant maintenance schedules, and regular lubrication of the ropes with a mixture of 95 per cent grease, of an approved type, and 5 per cent graphite. When renewal of the wires becomes necessary, the jib of the crane is lowered into its stowage, the sheave rope-guards are removed, and the old ropes unrove and replaced by the new ones. It must be remembered that the topping lift wires are of Lang's lay construction and may tend to unlay when being handled. Follow the advice given in Chapter 4, and watch the free end as it is rove; should any turns come out of the lay they should be replaced before the second end is anchored.

The ponder ball should be either lifted or removed during the periodical examination, for the purpose of surveying the covered portion of the purchase wire. Failure to inspect covered lengths of *any* wire has often led to very serious accidents owing to the wire failing through advanced corrosion.

Basic precautions

1. The crane driver must always be able to see the hand signals of the person in charge. If any signal is not understood no action should be taken unless the crane is moving; then it must be stopped.

2. To start a hoist from rest at any speed other than slow will cause shock loading, which may well damage the crane wires or its structure.

3. Do not depend on the operation of the electrical cut-out to keep the crane within its safe working arcs; a good crane driver constantly glances at the jib, the load and the superstructure adjacent to the crane.

4. Never attempt to hoist a load unless the crane is exactly plumbing the central lifting-point. To exert a sideways pull may damage the training gear, unship the purchase wire from the jib sheave, or damage the jib itself. To attempt to drag a load across the deck until it finds its own plumb will strain the topping lift wires and impart to the jib considerable adverse stress.

5. When hoisting a boat by crane the same precaution should be taken as for a derrick hoist, i.e. the lifting weight of the boat, shown on pages 293 and 295, does not include bilge water or extra equipment or fittings.

Tests of cranes

All cranes are tested by dockyard officers at each ship refit, and the period between tests must never exceed 2½ years. Various tests are carried out, similar to those described for derricks and winches; the relevant orders are consulted before their commencement. A crane is a type of modern derrick and winch combined, and the tests are designed to test the crane and its electrical winches together, under all probable conditions of service. Test tally plates fixed on, or near, the crane show that the approved tests have been carried out.

EXTEMPORE RIGS OF DERRICKS, SHEERS, GYNS AND ROPEWAYS

When no suitable crane or derrick is available aboard or ashore for lifting a heavy object, some form of derrick, sheers or gyn must be specially rigged for the purpose. Apart from shipboard use, the seaman may be called upon to land, or to handle, heavy stores or equipment at places where normal dockside facilities are not available, and he may have to do this with his own ship's gear, supplemented sometimes by anything he can find ashore.

The *derrick* is a single upright spar; the swinging derrick consists of an upright spar with a swinging boom pivoted at its foot. *Sheers* consist of two upright spars with their heads lashed together and their feet splayed out. A *gyn* is a tripod formed by three spars with their heads lashed together. A *ropeway* consists of an overhead jackstay of rope set up between two sheers, or gyns, along which a travelling block is hauled back and forth.

Extempore methods of lifting heavy equipment aboard and ashore are in many ways similar. In this section some methods of erecting, rigging and working extempore lifting gear are described, and some remarks on the construction of

a raft are also included. Data and formulae for estimating stresses in derricks, sheers and their rigging will be found in Appendix I.

USES AND LIMITATIONS

Standing derrick

This is a single spar (fig. 6–25) stayed by rigging and having a tackle at its head for hoisting a load. Its head is supported by a topping lift, or, if there is no suitable overhead attachment point for a topping lift, it is supported by a *back guy*. *Side guys* are fitted to give lateral support, and if there is a suitable attachment point, a martingale or *fore guy* may be led downwards from the head to prevent the head from springing upwards or backwards when hoisting or lowering a load.

If it has an efficient topping lift led from a point vertically above the heel, the derrick can be slewed to a limited extent as well as being topped and lowered. If the load is heavy, or if a back guy is fitted, or if the topping lift attachment point is not vertically above the heel, slewing must not be attempted.

The safe working load of the derrick is governed by the size and material of the spar and the strength of the rigging gear available; all these factors are described in Appendix I. A light derrick may be used for erecting a heavier derrick or sheers.

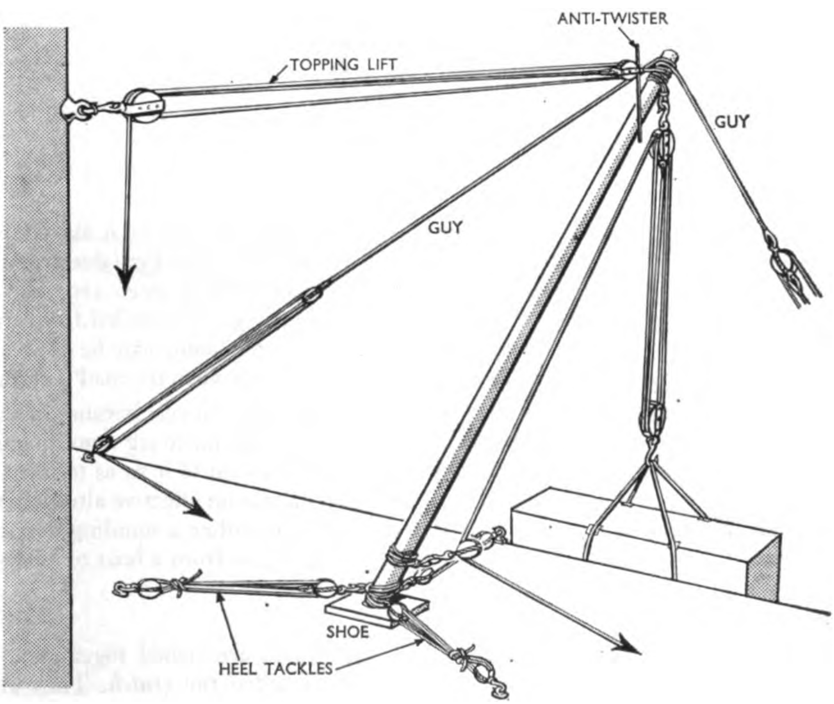


FIG. 6–25. Standing derrick

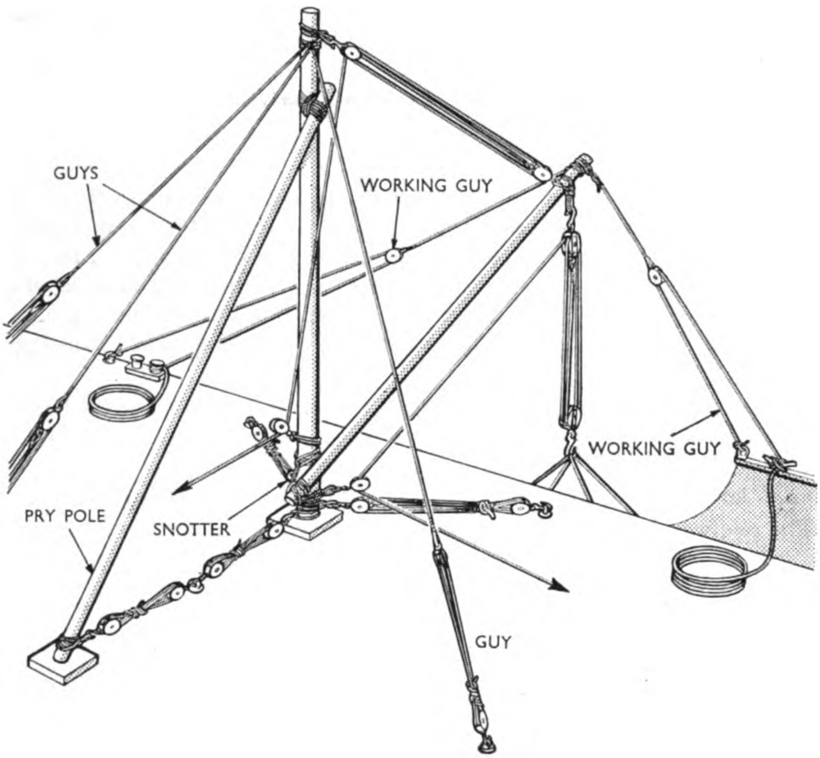


FIG. 6–26. Swinging derrick

Swinging derrick

This is made up of two spars (fig. 6–26), one upright and well stayed by guys, and the other secured to the first by a strop called a ***snotter*** (this type of snotter must not be confused with the snotter described on page 169) and a topping lift, so that it forms a swinging boom. Working guys are led from the head of the boom as in a permanent derrick, and the boom can be topped, lowered and slewed through an angle of up to 120 degrees when the load is slung.

A derrick of this type is not suitable for heavy loads, however, because of the stress imposed on the snotter. In addition, it is often difficult to rig a martingale (fore guy) for the upright spar, though another spar lashed to it so as to form a strut (called a ***prypole***), as illustrated in fig. 6–26, affords an effective alternative. Although this derrick is more complicated in rig than either a standing derrick or sheers, it is particularly useful for disembarking stores from a boat to a jetty.

Sheers

These consist of a pair of spars called *legs*, which are lashed together and crossed near their heads (fig. 6–27); the cross is called the *crutch*. They are supported in a vertical or an inclined position by rigging, and a tackle for hoisting the load is secured to the crutch. The overhead rigging consists of

either a topping lift and martingale or a back guy and fore guy; as sheers need no lateral support, side guys are not fitted. If a topping lift is fitted it should be led to a point aloft so that it makes, as nearly as possible, a right angle with the sheers *when they are loaded*. If a back guy is fitted it should be led to a point equidistant from the heels of the legs and making as broad an angle as possible with the sheers.

Sheers can be topped up or lowered through a limited angle, the extent depending upon the lead of the topping lift; if a back guy is rigged, however, neither sheers nor derricks may normally be canted to an angle of more than 20 degrees with the vertical. As sheers are made from two spars they are, of course, stronger than derricks of equal size and of the same material, but they are clumsier and take longer to rig. Sheers are particularly suited for use when the load is not required to be slewed, such as on the edge of a wharf or the

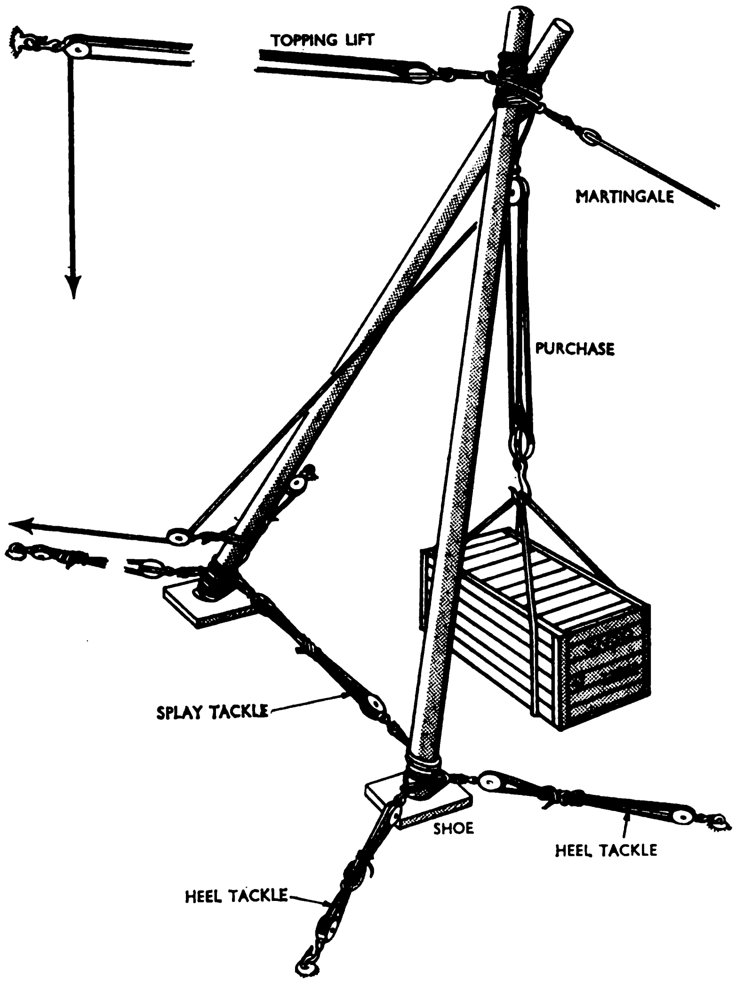


FIG. 6–27. Sheers

banks of a river, or in lifting a weight from a boat to the deck of a ship or assisting in the erection of a heavy derrick or sheers.

Gyn

A gyn (fig. 6–28) consists of three spars with their heads crossed and lashed together and their heels splayed out to form a tripod. A gyn is stronger than sheers and standing and swinging derricks, and it requires no rigging to support it, but it can be used only for a straight lift and cannot normally be traversed with its load slung.

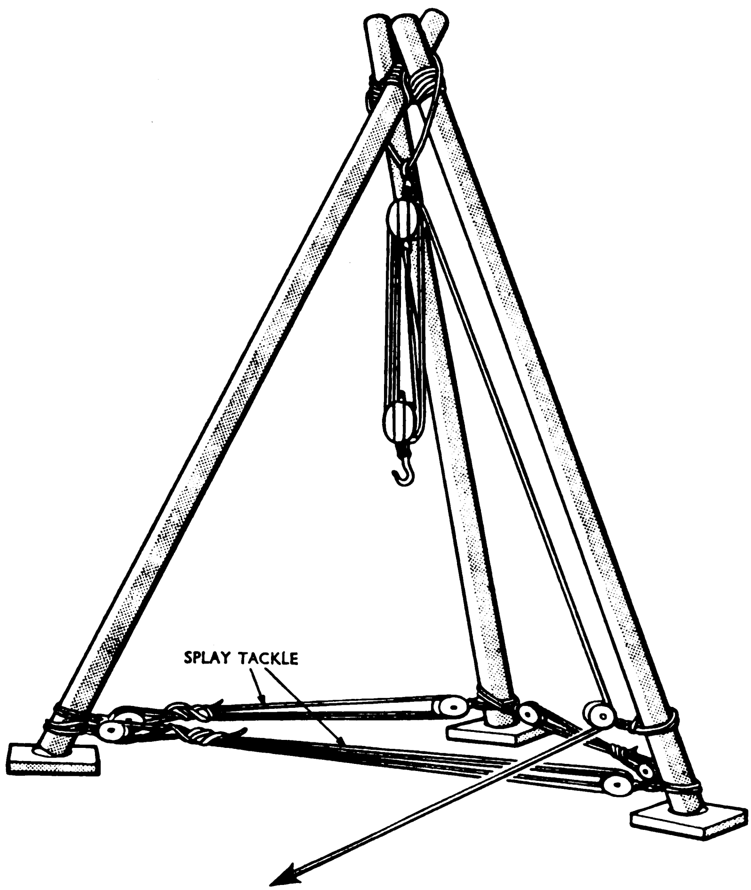


Fig. 6–28. A gyn

Ropeway

A ropeway (fig. 6–29) is used to transfer loads across a river or a ravine. Gyns are preferable to sheers as supports for the jackstay, because they are more stable and need less guying. An extempore ropeway is usually confined to transferring light stores and equipment, because of the heavy stresses set up

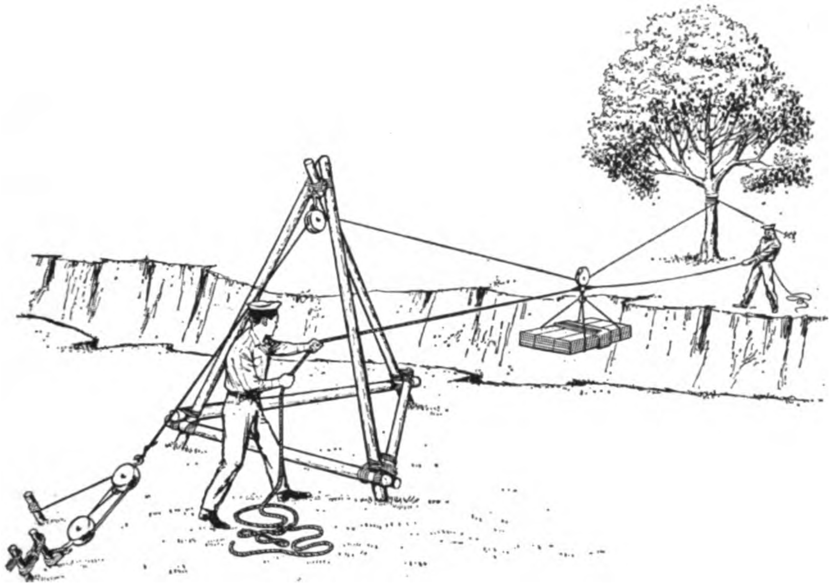


FIG. 6–29. Simple ropeway

in the jackstay (described in both Volume I (page 197) and in this chapter (page 179) and illustrated in fig. 6–13) when transferring a load; a 200 ft, 3 in., F.S.W.R. jackstay, for example, is limited to a maximum load of only 22 cwt using a factor of safety of 4.

PRINCIPLES OF USING THE GEAR WHEN RIGGING DERRICKS, SHEERS, GYNS AND ROPEWAYS

The rigging for derricks, sheers, gyns and ropeways must be led so that it does its work efficiently. As already stated, the best lead for a topping lift is at right-angles to the derrick and towards a point vertically above the heel, but this will often not be possible in practice; an angle of 60 degrees or more between the topping lift or back guy and the derrick will be reasonably effective, and it should never be less than 45 degrees. Similarly, the angle between the side guys and the derrick should, if possible, be 60 degrees or more, and these should not be inclined at a greater angle than 30 degrees—i.e. at a slope of not more than 1 in 2—with the horizontal.

Guys

The guys of derricks and sheers, particularly those used for heavy loads, stretch considerably when under load, and all guys must therefore be working guys so that their tensions can be adjusted. When picking up a load, a derrick or sheers should be heeled to a few degrees less than the required angle to allow

for the stretch in the topping lift or back guy; with heavy sheers this allowance may be as much as 8 degrees.

For light derricks or sheers the guys are usually wire pendants tailed with luff tackles, but for heavy derricks and sheers the guys should be at least runners rove through blocks at the head of the derrick or sheers and tailed at their hauling part with luff tackles or two-fold purchases.

If sheers are required only to traverse a load as far as their heels, the martingale (or fore guy) only acts as a preventer and therefore may be about half the strength of the topping lift or back guy; but if a load is to be traversed to a position behind their heels it must be of equal strength.

If a derrick is required to slew a load through an angle of less than 90 degrees the side guy on the training side and the martingale (or fore guy) act only as preventers and need not be as strong as the other guys or topping lift; but if the slewing angle is 90 degrees or more, all guys and the topping lift should be of equal strength.

To give a guy a slope of 1 in 2 when ashore and on firm and level ground, the distance of a *holdfast* (described on p. 201) from the foot of a derrick or sheers should be twice the effective length of the derrick or sheers, and to give it a slope of 1 in 3 it should be three times the effective length. To obtain the correct lead for the guys on sloping ground the uphill and downhill holdfasts must be placed respectively closer to and farther from the foot than is normally done (fig. 6–30). If a guy holdfast is inaccessible—for example, an anchor laid off

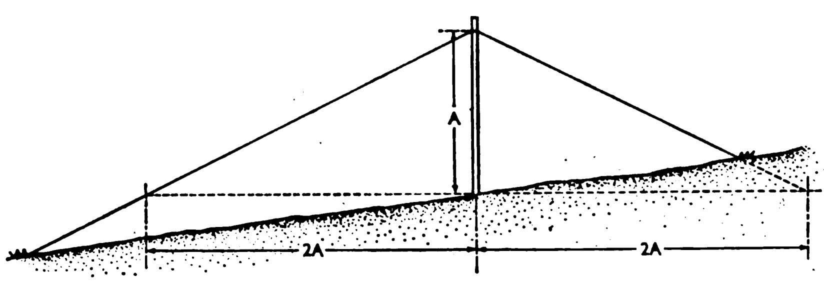


FIG. 6–30. Correct lead for guys on sloping ground

shore—the hauling part of the guy tackle must be led to the head of the derrick or sheers and thence to the foot.

Shoes

A shoe for a light derrick, sheers or a gyn is usually a square slab of hardwood with a recess in its upper surface to take the heel of its spar. The length of each of its sides should not be less than four times the diameter of the spar. For heavy spars the shoe is of metal or made up from baulks of timber. A shoe is used to distribute the weight of the load and the thrust of the spar over an area of deck, or, when used ashore, to distribute the weight so as to prevent the spar from sinking into the ground. When used ashore the shoe should be sunk level with the surface and held in place by *pickets* (described on page 203)

driven in at intervals along its sides and with their heads flush with the shoe.

Shoes should always be used for extempore spars, except when handling light loads, and must be placed at the same level; otherwise an undue stress will be placed on one of the legs and the sheers or gyn will tend to capsize. When using spars aboard ship, the deck on which they stand must be well shored up below.

Heel tackles

These tackles are used to prevent unwanted movement at the heel of spars used for derricks and sheers. However, the heel tackles can be used to move sheers about the deck if required. The angle between the tackles should be 120 degrees wherever possible (fig. 6–27).

Splay tackles and belly tackles

A splay tackle is used to prevent the heels of spars from moving further apart (figs. 6–27 and 6–28). Belly tackles are secured to the middle of a spar when there is any doubt concerning its strength for a particular job. The spar is then stayed to the deck or ground. Alternatively, the spar can be *fished*, as described on page 216.

Holdfasts for use on shore

In a man-of-war it is a relatively simple task to find eyeplates or other permanent fittings to holdfast extempore rigging; but when ashore, and probably under adverse conditions, the seaman must find or construct an anchorage to hold his extempore gear firmly and safely in place. Holdfasts (fig. 6–31) may consist of any of the following:

1. existing natural or structural features, such as trees or masonry,
2. pickets driven singly or in combination into the ground,
3. baulks of timber placed behind a line of driven pickets,
4. ships' anchors embedded in the ground and held by driven pickets, or laid under water in the normal way,
5. baulks of timber buried in trenches dug in the ground.

Whatever the type of holdfast, it must be more than strong enough for the stress it is intended to bear, because once a holdfast starts to give it is difficult to strengthen it. A holdfast must be so arranged that the maximum resistance it can offer is in line with the stress it must bear; a buried baulk of timber, for example, should lie at right-angles to the pull, whereas a combination of pickets should be driven exactly in line with the direction of the pull.

Existing holdfasts should be used whenever it is practicable, provided that they are conveniently situated and strong enough for the job. The holding power of a tree is uncertain, because so much depends on the depth of its roots and the nature of the soil; a tree can be considerably strengthened, however, by fitting it with a back guy, and if two trees are growing close together their combined holding power can be used by placing a baulk of timber across them. A baulk of timber placed across a gap in masonry makes a good holdfast, provided that the stress is distributed over a sufficiently large area of the masonry by placing planks vertically and horizontally between the baulk and the masonry.

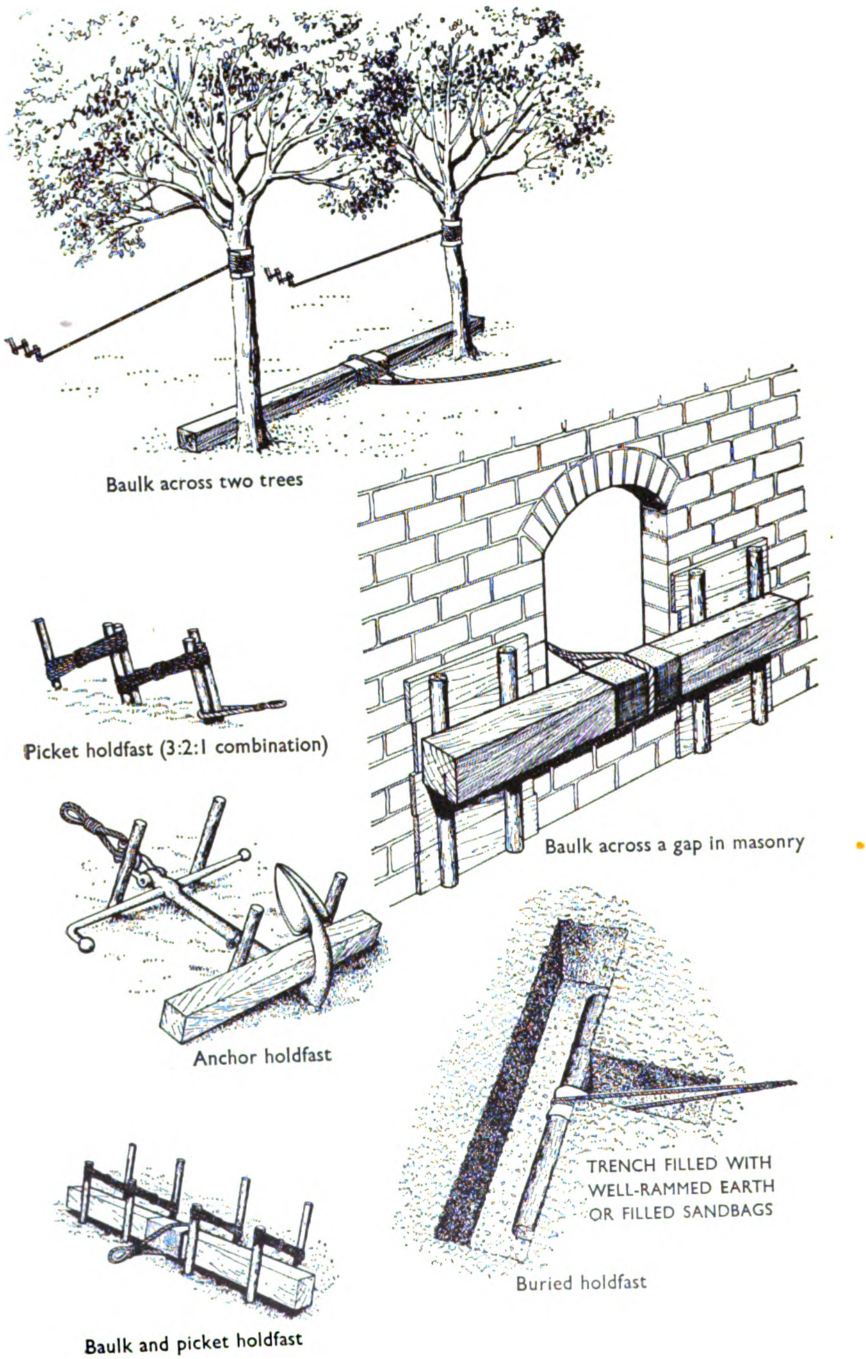


FIG. 6–31. Holdfasts

The pier of a bridge or the base of a tower can be used by encircling it with a strop, but care should be taken to protect the strop from chafe and bad nips.

Picket holdfasts may be used in ordinary soil for pulls not exceeding two tons. The normal picket is an ash stake 5 ft long and 3 in. in diameter, with one end pointed (and, when possible, shod with iron) and the other end bound with an iron hoop; it should be driven to a depth of 3 ft at an inclination of about 20 degrees with the vertical. Pickets may be used singly or lashed together in combinations of one-and-one, two-and-one, or three-two-and-one, as shown in fig. 6–31.

A *baulk and picket holdfast* consists of a baulk of timber placed behind a line of driven pickets which are backed by another line of pickets; it may be used for pulls of between 2 and 10 tons. Only two lines of pickets should be used, driven in in combinations of one-and-one or two-and-one, with each combination at least 18 in. from the next. A three-two-one combination of pickets should not be used, because of the difficulty of driving the pickets so that each will bear its fair proportion of the stress. The front row of pickets should be exactly in line so that the stress on the baulk is divided equally among them, and the ground under the baulk should be cut away to allow the face of the baulk to bear fairly against the inclined pickets (fig. 6–31). The baulk should be well parcelled where the strop passes round it.

An *anchor holdfast* consists of an Admiralty pattern anchor embedded and supported by pickets, as shown in fig. 6–31. If the pull is horizontal it will take a stress up to the strength of its ring, but it is not very suitable as the holdfast for a guy, because the upward pull of the guy tends to dislodge the anchor. When an offshore underwater holdfast is required for the fore guy of a derrick or sheers the anchor should be laid in a position which gives the guy plenty of scope, and its angle of slope should not be steeper than one in three; that part of the guy which will be under water should be of chain. Backing one anchor with another gives greater holding power, provided that the anchors are well separated.

A *buried holdfast*, used for pulls of over 10 tons, consists of a baulk or baulks of timber laid in a trench and then covered with well-rammed earth. The trench should be 2 ft longer than the baulk and have a vertical face; its depth will depend on the nature of the soil and the pull which the holdfast is required to withstand. A subsidiary trench to take the strop must be cut, as shown in fig. 6–31; its slope should not be steeper than one in three and chocks should be placed to support the baulk clear of the bottom of the trench to enable the strop to be passed. Planks can be laid vertically and horizontally between the baulk and the face of the trench to distribute the stress over a greater area.

Details concerning the strength of timber are included in Appendix I.

RIGGING DERRICKS, SHEERS, GYNS AND ROPEWAYS

Obstructions in the vicinity, lack of a clear lead for purchase, topping lift or guy, and other special circumstances make it impossible to give detailed instructions for rigging these appliances, so the seaman must achieve the best he can with the available equipment.

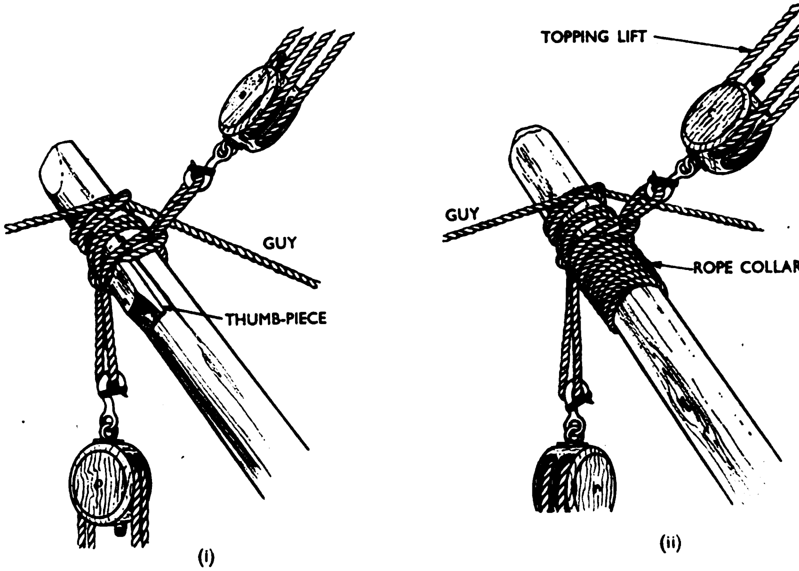


FIG. 6–32. Methods of rigging the head of a derrick, using rope collars or thumbpieces

To rig a standing derrick (figs. 6–25 and 6–32)

Strops for attaching the purchase and topping lift (or back guy) are first placed over the derrick head, and prevented from slipping down either by wooden projections called *thumbpieces* (fig. 6–32(i)) screwed or nailed in place, or by a rope *collar* (fig. 6–32(ii)) put on the spar like a whipping. These strops should lie close together so as to avoid a bending stress on the spar. The guys, which consist of single parts of cordage or wire rope, are then middled and clove-hitched over the head of the spar, above the strops, tackles being attached if required. The distance from the foot of the derrick to the point of attachment of the purchase and topping lift is known as the *effective length* of the derrick.

The heel of the derrick is kept in place by tackles, which must be led so that they will support it in every direction, and particularly from that in which the derrick will be raised and lowered. The strops for the heel tackles must be kept as low as possible, otherwise the tackles will be heavily stressed as the derrick is raised.

The fall of the purchase is rove through a leading block secured to a strop round the heel of the derrick, the strop being prevented from slipping up by thumbpieces or a rope collar.

To rig a swinging derrick (figs. 6–26 and 6–32)

The upright spar is first erected, and is inclined somewhat away from the load so that it will become vertical as the boom takes the weight. It must be well supported by guys, each strong enough to take the entire pull of the topping lift as the boom swings round. The arc through which the boom is required to

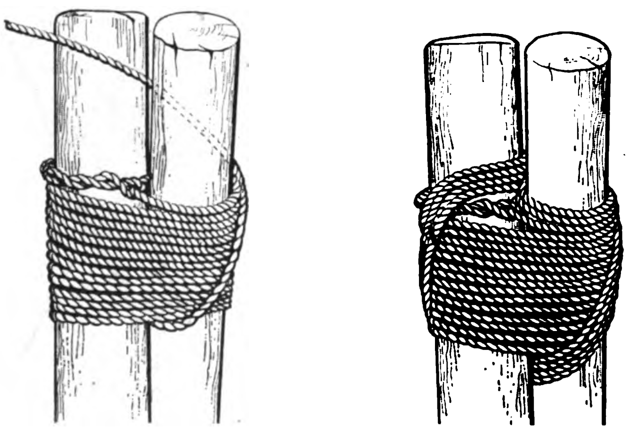
swing must, of course, be left clear. A strop to take the upper block of the topping lift is placed over the head of this spar above the guys.

The spar which is to form the boom is now laid midway between the intended limits of its horizontal travel, and with its heel close against the upright spar and projecting on the side away from the load. The head of the boom is rigged as for a standing derrick, but the heel is attached to the upright by means of the snotter, as shown in fig. 6–26. If no suitable strop for the snotter is available a bight of rope can be passed round the boom, then through its own bight, and then half-hitched and dogged round the upright spar in the same way as a stopper is put on a wire rope (see Volume I). The falls of the topping lift and purchase are led through blocks shackled to strops at the foot of the upright spar, the strops being kept in place by thumbpieces or rope collars. As the leading block for the hauling part of the purchase fall is to one side of the boom, the latter is subjected to a sideways pull when the purchase takes the weight, and the boom must therefore be adequately guyed.

In order to keep the stresses on the boom, topping lift and guys to a minimum the boom should cross the upright as low down as possible without fouling the ground or deck, and the effective length of the boom (from where the spars cross to where the topping lift and purchase are attached) should be as short as the reach required for the derrick will allow.

To rig sheers (figs. 6–27, 6–33 and 6–34)

The spars for the legs are laid side by side, with their heels together and their heads supported conveniently clear of the ground or deck; those parts which will be covered by the lashing are then parcelled to prevent chafe, and the heads are then lashed together as described below and illustrated in fig. 6–33. The legs are first crossed and the lashing made fast to one of them by a timber hitch, either above or below the cross, and then a sufficient number of



(I) (II)

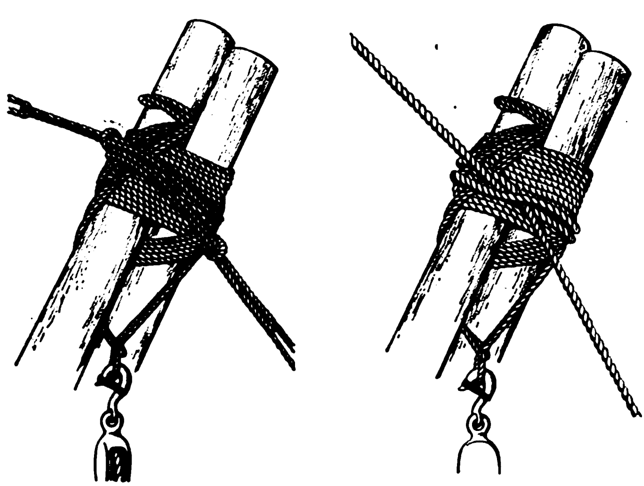
FIG. 6–33. Passing the head lashing of sheers

round turns (usually 14 or more) to cover the cross are taken round both legs. The end is then brought up between the legs, passed down between them on the opposite side of the cross, and brought up again as before, so as to form a frapping turn binding the whole lashing together. Four or five of these frapping turns having been applied, the lashing is completed by a clove hitch taken round the opposite leg to the one to which it was originally attached; it is important that the frapping turns are correctly put on, close to each other, and hauled taut. Choice of the rope to be used for the head lashing depends on the size of the spars and the weight to be lifted; this is best judged by experience, but the following is given as a general guide:

Weight to be lifted	*Lashing*
Up to 2 tons	2½-in. manila
From 2 to 5 tons	2-in. F.S.W.R.
From 5 to 20 tons	2½-in. F.S.W.R.

When the head lashing has been completed the heels of the legs are opened out to the required distance; the action of opening them out sets up the head lashing so taut that it binds the legs securely together where they cross. The strop for the purchase is now put on and must be long enough to enable the block to swing clear between the legs; it is put on by slipping it up the top leg and passing it down over the head of the lower leg, so that it will bind the two together when under load (fig. 6–34). Pads of canvas must be placed under it to prevent it from chafing the lashing.

The topping lift and martingale, or fore and back guys, are then secured to the head of the sheers. There are several equally good ways of doing this, two of which are illustrated in fig. 6–34 and in each of which the principles are that the pull of the guys should assist in binding the sheers together, and that the purchase strop should be free to take up its natural position as the weight comes on it.



(i) (ii)

FIG. 6–34. Head of sheers—methods of rigging

The necessary tackles for the guys and other rigging are then shackled to the strops or clapped on to the ends of the ropes, as required; and finally a small block is attached to each leg above the cross and a single whip then rove through each to serve as gantlines for sending a man aloft to make any adjustments after the sheers have been raised. The rigging of the head of the sheers has now been completed.

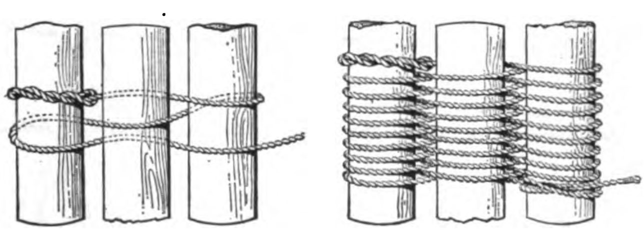
The sheers are then placed roughly in position ready for raising, the heels being pointed to the shoes prepared for them and supported laterally by *splay* and *heel tackles*. The distance between the shoes should be one-third of that from the foot of the sheers to the crutch, which is the effective length of the sheers. As its name implies, the splay tackle leads from the heel of one spar to the heel of the other, being secured to each by a strop. The heel tackles guy the heels laterally and, as with a derrick, their strops should be kept as low down as possible.

The leading block for the fall of the purchase is then attached to one leg, and, after fitting thumbpieces or rope collars to prevent all the strops at the feet of the legs from slipping upwards, the sheers are rigged and ready for raising.

To rig a gyn (figs. 6–28 and 6–35)

The position for the head lashing is first marked on all three spars which are to be used for the legs. These legs are then laid parallel with each other, an inch or two apart and with the heel of the centre leg pointing in the opposite direction to those of the other two. The centre spar is called the *prypole* and the other spars the *cheeks*. The marks must be in line and the heads of the legs should be supported clear of the deck.

The lashing is then put on at the marks. It is begun with a timber hitch round one cheek, then from six to eight figure-of-eight turns are taken, as shown in fig. 6–35, and the lashing is completed with a clove hitch round the other



(I) (II)

FIG. 6–35. Passing the head lashing of a gyn

cheek. The lashing must be applied loosely: it cannot slip down once the gyn is erected, and if it is too taut great difficulty will be experienced in raising the gyn; it is usual, however, to place a rope collar round the prypole below the lashing to prevent it slipping down during the process of raising.

The heels of the cheeks are now opened out, and the splay tackles are rigged between the feet of each pair. The gyn is then raised by lifting its head and hauling the heel of the prypole towards the heels of the cheeks by means of the splay tackles. When the head reaches a convenient height the strop for the upper

block of the purchase is put on and the block itself secured to it. Then tackles are rigged as required to haul the feet into place on their shoes. When correctly placed the feet are secured by lashing or heel tackles led so as to give the necessary lateral support, and the hauling part of the purchase is led through a block secured to the heel of one cheek. As with derricks and sheers, thumbpieces or rope collars are required to prevent the strops at the heels from slipping up the spars. With very small gyns splay tackles are not necessary, and their feet can be manhandled into place and then secured, either by lashings or by short spars lashed across them.

To rig a ropeway (figs. 6–29, 6–36 and 6–37)

Where no suitable trees are available for supporting the jackstay of a ropeway, gyns or sheers must be used. Gyns are preferable to sheers because they are more stable, but sheers may have to be used for long jackstays with a high ground clearance if suitable spars are available.

The stresses set up in a jackstay are considerable and in practice can be taken as being up to five or six times the weight of the load. Strong holdfasts must therefore be provided for the jackstay or any back guys, and they should be placed so that the slope of the jackstay or guy from the ground to the head of the support is not steeper than one in four. The tauter a jackstay the greater will be the stresses imposed on its anchorages and supports, but the easier it will be to haul the load across. On the other hand, if the jackstay is too slack, though the stresses in it will be reduced it will be difficult or impossible to haul the load across, and also the ropeway will tend to become laterally unstable. The practical compromise between these extremes is to adjust the tension in

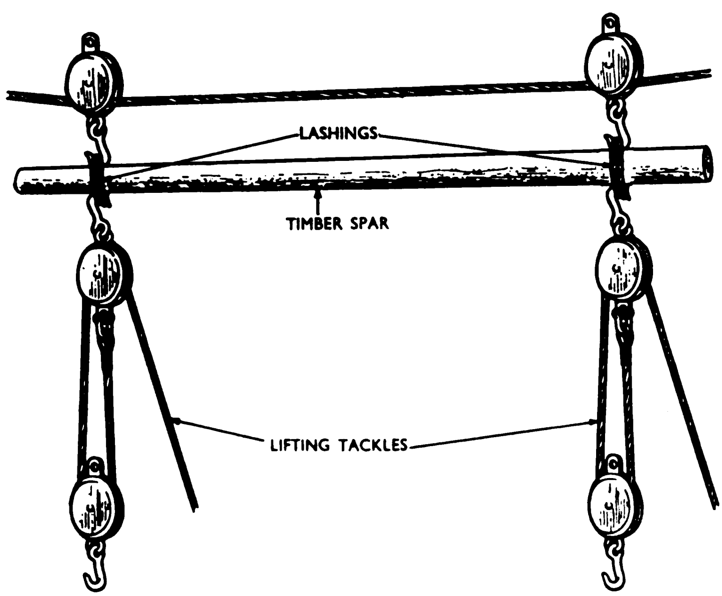


FIG. 6–36. Traveller for slinging heavy weights on a jackstay

the jackstay to give it a dip of between one-fiftieth and one-twenty-fifth of its effective length when unloaded, so that when loaded at its centre it will assume a dip of between one-twentieth and one-tenth of its effective length. For practical purposes the dip in the jackstay when loaded at its centre should not exceed one-tenth of its effective length.

The jackstay can be rigged with each end secured to a holdfast and rove through a block slung from the head of each of its supports; or its standing end can be secured to the head of one support, which will then require a back guy. It is usually set up by a tackle on its running end, but for heavy loads its final adjustment must be made by a rigging screw.

The traveller can be an inverted block hooked to a light tackle for hoisting the load to the required height before it is traversed, but for heavy loads the traveller should consist of two blocks lashed to a spar fitted with two lifting tackles, as shown in fig. 6–36.

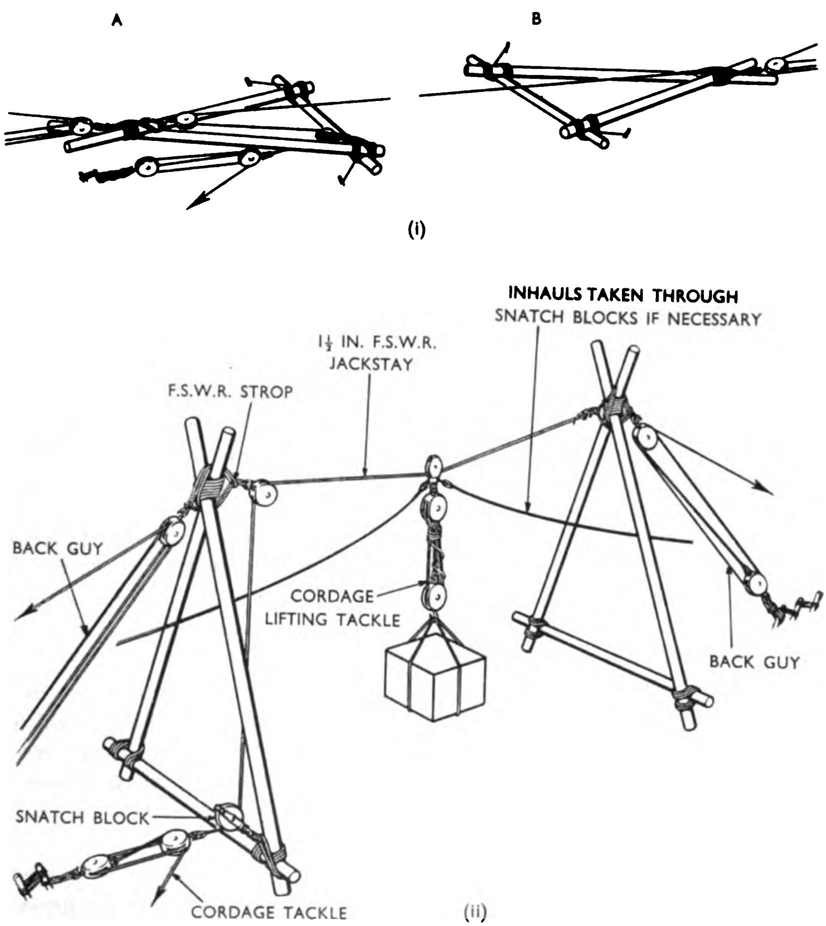


FIG. 6–37. A light ropeway

The gyn or sheers must be stepped sufficiently far back from the edge of the gap to allow room to sling the gear on one side and land it on the other. For light loads no leading blocks are required for the traveller inhauls or outhauls, but for heavy loads the inhaul should be led through a leading block at the head of the gyn or sheers but below the jackstay block. If gyns are used each should be stepped with the heel of its prypole towards the gap but slightly to one side of the jackstay, and the inhaul should be led on the opposite side of the prypole to the jackstay. A simple ropeway using a gyn and a tree as supports is shown in fig. 6–29.

A method of rigging a ropeway between two sheers in which the jackstay is used to erect both sheers is shown in fig. 6–37. The sheers are laid with their heels facing each other and with the standing end of the jackstay secured to the head of the sheers marked *B*, which are temporarily secured to the ground. The sheers marked *A* are first raised as high as possible by hand, and then to their full height by hauling on the tackle at the hauling end of the jackstay. The back guy of sheers *A* is then set up and sheers *B* are raised in a similar manner.

RAISING DERRICKS AND SHEERS

The various methods of raising a derrick described here can be applied equally well to sheers. It is assumed that the derrick is fully rigged with its head lashing, main tackle, guys and heel tackles, and that its heel is pointed towards its shoe. As the derrick is swayed up the side guys must be tended to keep the head in the fore-and-aft line, and the heel tackles must be tended to guide the foot into the shoe and then to prevent it from slipping. Before the derrick becomes vertical the martingale or fore guy must be tended to prevent the derrick from falling backwards.

A derrick is hauled upright mainly by its topping lift or back guy, but its head must first be raised high enough to allow the pull of the guy to exert an effective leverage without putting undue stresses on the guy, the derrick and its heel tackles. The head of the derrick must therefore be raised initially by some means until the angle between the back guy and the derrick is between 15 and 20 degrees; the greater this angle the less will be the stresses involved. Lowering derricks or sheers is carried out in the reverse manner to that in which they are raised.

By manhandling

The head of a light derrick can be manhandled to the required height by means of a long handspike placed under and athwart the derrick head, which is then lifted by two or more men on each end of the handspike. A low trestle should be placed under the derrick and worked towards its heel with each lift until the head of the derrick has been raised high enough.

By moving lever

This method (fig. 6–38) is suitable for a derrick which is rather too heavy to be raised initially by manhandling, and which is fitted with a back guy consisting of a pendant tailed with a tackle. The lever should be a light spar about

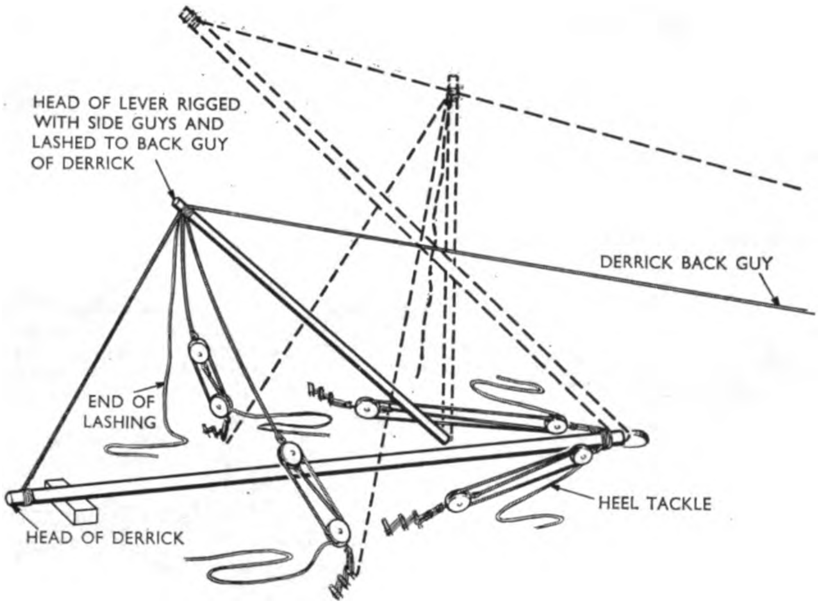


FIG. 6–38. Raising a derrick by a moving lever

half as long as the derrick and fitted with side guys, and it is placed alongside the derrick, with its heel at about a quarter of the way from the heel of the derrick to its head. The head of the lever is then lashed to the back guy at a position which will allow it to be raised through an angle of at least 45 degrees before it begins to raise the head of the derrick (fig. 6–38). The lashing is made with figure-of-eight turns and finished with a slip knot, and its end should be long enough to enable the lashing to be slipped from the ground as soon as the lever ceases to act.

The head of the lever is raised initially by manhandling and then by the back guy, while its head is kept over the derrick by means of its side guys. When the lever has been raised through an angle of about 45 degrees it will begin to raise the derrick and will continue to do so until it is a little beyond the vertical, when it will cease to act. At this stage the lashing is slipped and the lever is withdrawn, otherwise it will be lifted off the ground as the derrick is raised by its back guy. The derrick side guys are not shown in fig. 6–38.

By standing lever

This method (fig. 6–39) is suitable for a rather heavier derrick which is fitted with a back guy rigged as a runner and tailed with a purchase. The lever can be a spar or light sheers, and its length and position in relation to the derrick are the same as those for a moving lever. The lever is fully guyed with strong fore and back guys and is fitted with an extra guy on the side where the hauling part of the back guy is rove. If the lever is a spar a slot is cut in its head into which is placed the standing part of the back guy; if sheers are used as a lever the standing part is placed over the crutch. The lever is then raised and its

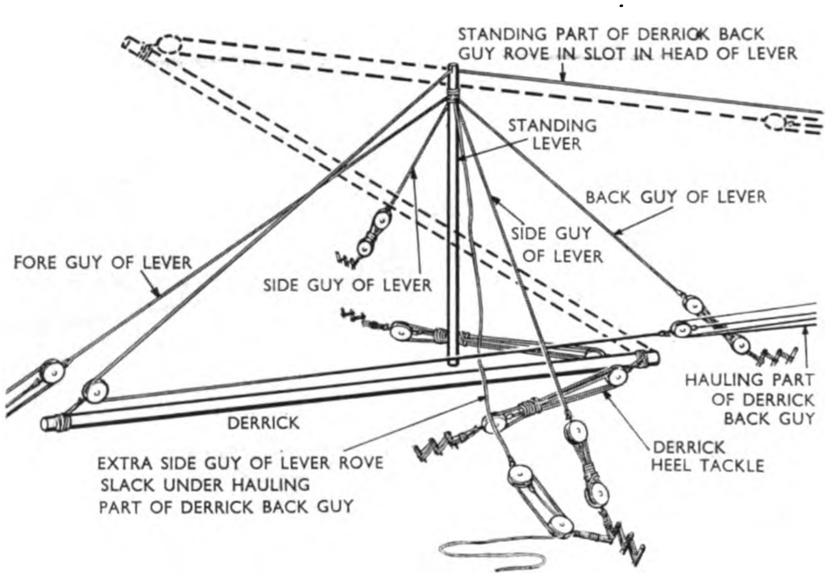


FIG. 6–39. Raising a derrick by a standing lever

guys are set up, except the additional side guy, which is rove *underneath* the hauling part of the back guy and left slack.

The derrick is then raised by hauling on its back guy, and as the head rises so the hauling part of the back guy will rise until it fouls the side guy of the lever. Raising the derrick is then halted while the additional side guy of the lever is set up and the other side guy is cast off. The raising of the derrick is then completed by means of its back guy. The derrick side guys are not shown in fig. 6–39.

By auxiliary derrick

This method (fig. 6–40) is used to raise the heaviest derricks and sheers. The position of the auxiliary derrick relative to the main derrick is important, because the stresses involved in raising may approach the limits of the strength of the gear. The nearer the auxiliary derrick is to the head of the main derrick the less will be the stresses in the auxiliary derrick, but the less also will be its initial lift, and so a greater pull will be required on the back guy to continue the raising. Conversely, the farther the auxiliary derrick is from the head of the main derrick the greater will be the stresses on the auxiliary derrick, but the higher will be its initial lift and so a lesser pull will be required on the back guy to continue the raising. The best position for the auxiliary derrick in relation to the main derrick is given by the following formula, in which it is assumed that the purchase of the auxiliary derrick is hooked to the main derrick at its head lashing:

$$d = \sqrt{A^2 - (B - 1\tfrac{1}{2})^2}$$

where:

d is the distance in feet of the heel of the auxiliary derrick from the heel of the main derrick (or line joining the feet of the sheers),

A is the effective length in feet of the main derrick,
B is the effective length in feet of the auxiliary derrick.
(The width of the auxiliary derrick's purchase is assessed at 1½ ft.)
The auxiliary derrick must be fully guyed and, if heavy, it may itself have to

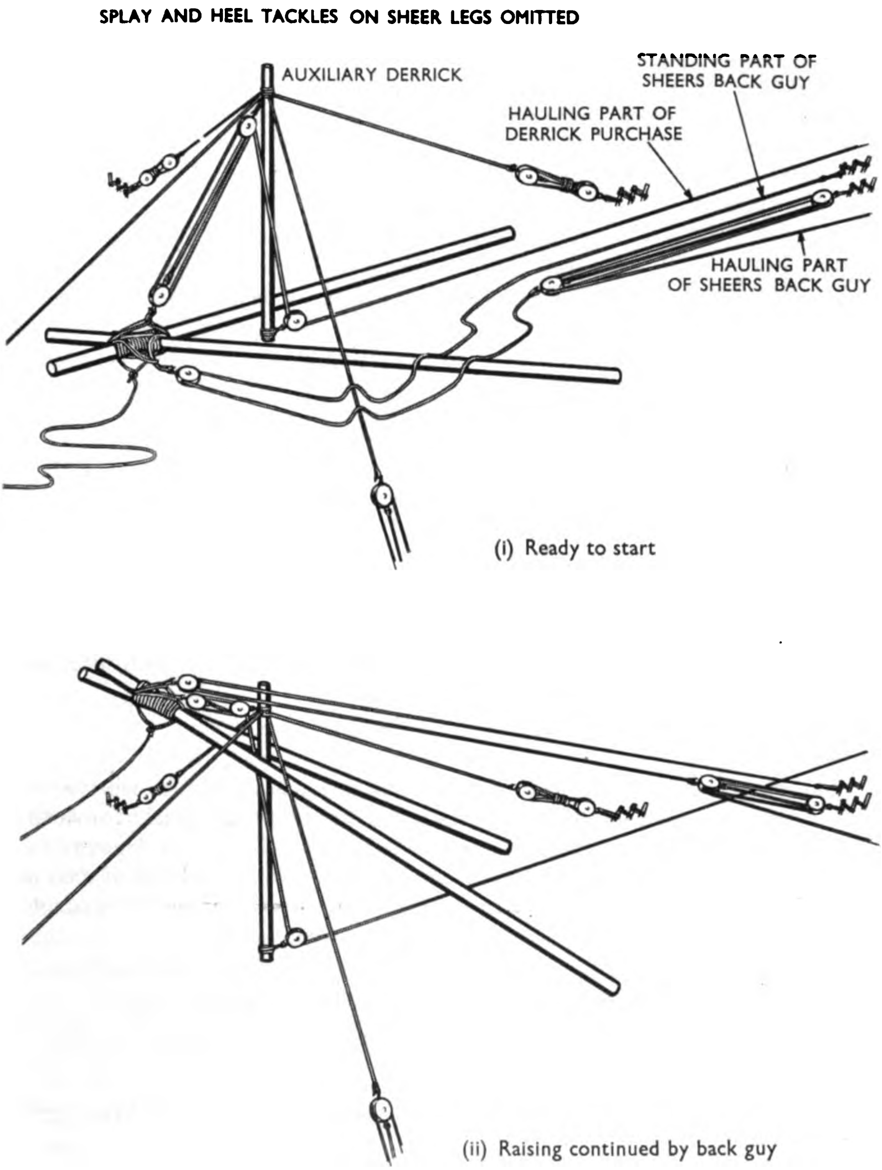


FIG. 6–40. **Raising sheers by auxiliary derrick**

be raised with the help of a lever. When raised it should incline a little backward from the vertical to allow for the stretch in its back guy as it takes the weight of the head of the main derrick.

When raising a heavy derrick the head of the auxiliary derrick must be kept in the fore-and-aft line of the main derrick.

Walking a derrick or sheers

If it is not convenient to erect a derrick at the place where it is required, it must first be rigged and raised and then *walked* there. It is not usual on shore to walk a derrick on its shoe; the shoe is first embedded in its proper position and the derrick is then walked over the ground to the shoe. If the ground is too soft it is walked along a pathway of planks, reinforced if necessary by baulks of timber.

To walk a derrick, cross-lash a spar to its foot about 2½ ft above the heel (above the ground for sheers); then, by lifting on the spar, levering the heel(s) with handspikes, and hauling on the forward heel tackles, the derrick or sheer is walked towards its shoe(s). A derrick must be kept upright by adjusting the side guys. If fitted with a strong fore guy, walking is facilitated by inclining the derrick or sheers backwards about 10 degrees; a rear heel tackle must be fitted—otherwise the inclination should be slightly forward.

PROVISION OF POWER

Heel tackles and all but the heaviest guys are usually manhandled. The main lifting tackles may be manhandled, but are usually worked by hand- or power-driven winches or capstans, because the tackles must be worked as smoothly as possible to avoid increasing stresses, and the load must be both lifted and held suspended.

Manpower

The force a man can be expected to exert depends chiefly on whether the effort required is momentary or sustained, whether it is made quickly or slowly, and on the manner in which the force is to be applied. It also depends to a certain extent on the number of men employed: the larger the body of men the less will be the individual effort. In parties of up to 30 men, and for sustained efforts, each man can be expected to do the following work:

1. Exert a standing pull of from 56 to 90 lb (e.g. on the fall of a tackle)
2. Exert a walking pull of from 40 to 50 lb (e.g. on a purchase fall)
3. Push or pull with a force of from 15 to 20 lb (e.g. on a winch handle)
4. Carry from 56 to 90 lb (e.g. when carrying a spar or a girder).

In parties of up to four men, and for short periods only, each man can be expected to work as follows:

1. Exert a standing haul of from 120 to 130 lb (provided he has a good foothold)
2. Exert a stationary push of 100 lb (provided he has a good foothold)

3. Bear down on a lever with a force of from 70 lb to his full weight
4. Lift up on a lever at knee-level with a force of 150 lb
5. Carry on his shoulders a weight of 130 lb.

Hand winches

A hand winch is designated by the maximum pull which can be applied by it, i.e. 1, 3, 5, 8 or 10 tons; in practice, however, only about seven-tenths of its maximum pull can be applied by the men working a winch. The number of men who can work on each handle varies from two to four, depending on the size of the winch. To prevent a winch up-ending when under load it must be bolted to wooden bearers, which should project far enough in front of the winch to ensure that the up-ending moment is balanced by the weight of the winch on the rear end of the bearers. The bearers themselves should be braced together and secured from moving by pickets driven in in front of them, and their rear ends should be secured to a holdfast. The length of the bearers required for a particular pull on the winch rope, and the rope capacity of a winch drum, can be found from formulae in Appendix I.

Purchases and tackles (see Appendix I)

The blocks of portable tackles used for extempore purposes must be kept as light as possible, otherwise the tackles would be too cumbersome to handle.

Up to a certain number, the more sheaves there are in a tackle the greater will be the gain in mechanical advantage, but thereafter any additional sheaves will reduce the gain in mechanical advantage because of the friction set up by them. Furthermore, the greater the number of sheaves in a tackle the heavier will be its blocks and the more cumbersome will it be to handle. For these reasons a three-fold tackle is usually the highest-ratio tackle used for general purposes, and in many cases it is better to use a combination of two lesser-ratio tackles than one of high ratio. For example, when used for hauling, a gun-tackle clapped on to a runner gives a higher mechanical advantage for a lesser velocity ratio than a three-fold tackle rigged to advantage. When using a combination of tackles, however, the velocity ratio must be taken into account if the fleeting space is limited and speed of operating is of importance. A luff upon luff, for example, provides about twice the mechanical advantage of a three-fold tackle rigged to advantage, but the velocity ratio of the former is more than twice that of the latter.

Leading blocks or rollers to guide the hauling part of the fall of a tackle to a convenient position or clear of an obstruction should be used sparingly, because the friction in each leading block or roller will reduce the mechanical advantage of the tackle by an amount proportional to the angle through which the fall is deflected. The friction caused by deflecting the fall through angles of 90 and 45 degrees will amount respectively to roughly a half and a quarter of the friction set up in a sheave of the tackle.

Tackles used for hauling should be rigged to advantage whenever possible, i.e. with the hauling part leading from the moving block. Hoisting tackles, however, must be rigged to disadvantage (unless a combination is used), because of the necessity of leading the hauling part downwards from the upper, or standing, block.

The blocks of a tackle are stronger than its fall, and in tackles rove with cordage falls and using a factor of safety of eight, the safe working load of a tackle is that of its fall. If a reduction of the factor of safety has to be accepted, then the safe working load of the tackle may depend on the strength of its standing block. But if there is any doubt about the safe working load of a tackle, the strength of its blocks should be compared with the safe working load of the fall, and the lower amount taken as the safe working load.

The table in Appendix I assumes that tackles and combinations of tackles for hauling are rigged to advantage, and those for hoisting are rigged to disadvantage.

SPARS

Derricks, sheers and shores are subjected to a longitudinal or buckling stress, and in this respect the strength of any particular spar depends upon its thickness, its length and the type of wood of which it is composed.

Timber for spars is designated generally as *selected* or *unselected*. By 'selected' is meant all new and well-seasoned timber, and also little-used old timber which has been kept dry and appears to be sound. All other timber must be considered as 'unselected'. The weights of various timbers and formulae for calculating their compressive and shearing strengths are given in Appendix I.

Fishing a spar

If a spar is considered too weak for the job in hand it can be strengthened either by the rigging of belly tackles or by *fishing* it. If a spar has been sprung, or broken by overloading (usually at the middle of its effective length), it can be repaired temporarily by fishing it. Fishing consists of lashing lengths of timber along the spar as when making a splint (fig. 6–41). If properly fished it will be strong but rigid; the description given is, however, intended to be followed in principle only, as details of an emergency repair must necessarily depend upon the circumstances and upon the gear available.

If broken, the ends of the spar are lined up carefully and married as closely as possible, usually with the aid of a maul, and are sometimes held in place by small pieces of wood or metal nailed across the join. The *fishing spars*, which may consist of lengths of any suitable material, such as 3-in. by 3-in. quartering, are spaced equidistantly around the break and lashed temporarily in place; their length should be not less than nine times the diameter of the broken spar, and they should lie closely to it throughout this length, small wedges or strips of wood being used as packing where necessary if the spar is of an awkward shape. In addition, any space between the spars must be filled in, usually with odd lengths of wood, to prevent them from slipping sideways beneath the lashing. The full length of the fishing is then tightly bound with a wire rope lashing put on as for a serving or a common whipping, and should the wedges beneath the temporary lashing tend to slack up they must be kept driven home as the

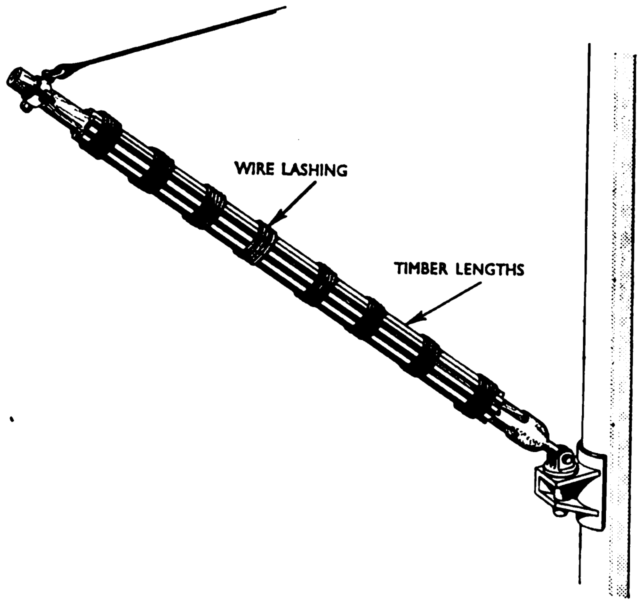


FIG. 6–41. A fished spar

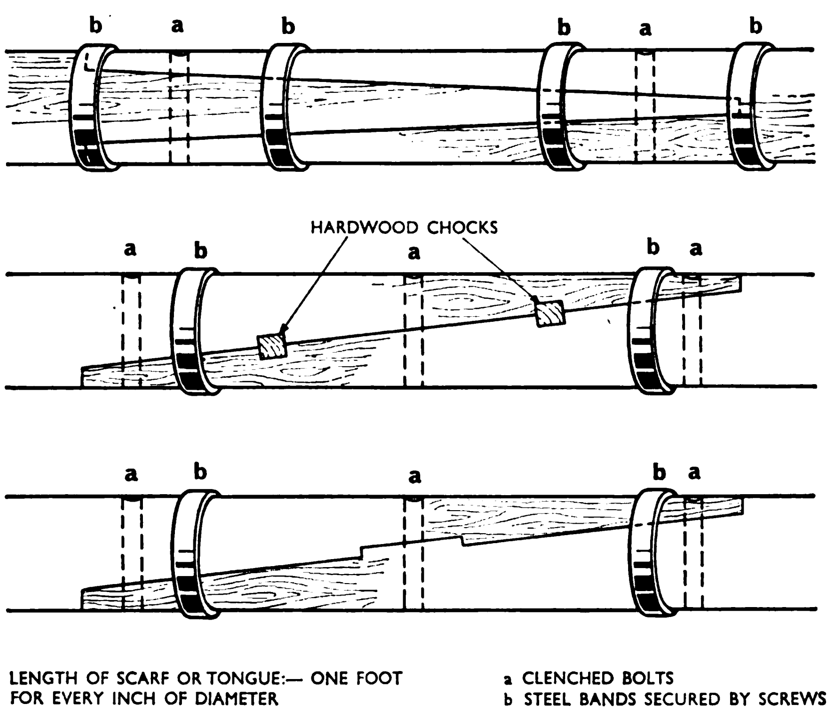


FIG. 6–42. Methods of scarfing a broken spar

binding proceeds. The temporary lashing is removed, piece by piece, as it is reached by the permanent binding.

Permanent repair of a spar

A permanent repair, which is flexible, can be achieved by *scarfing*, but this involves some shortening of the spar. Scarfing is a shipwright's job, the principles of which are shown in fig. 6–42.

Precautions

The load that a spar can safely be subjected to is not governed only by the formula given in Appendix I, but also by the swinging or effective radius of the spar and by its angle of tilt from the vertical. Seamen should be guided by the information contained in the preceding pages when they are required to use spars at increased radius or at less than their recommended safe topping angle.

Only gear in first-class condition should be used for work of an extempore nature, and with such gear a factor of safety corresponding to that which is shown in Appendix I is usually allowed. However, it may be necessary to reduce this factor of safety in order to provide gear which is light enough to be handled with the means available; but the factor of safety should not be reduced to less than three (except for timber, for which a factor of safety of two is usually used).

The hauling ends of all tackles should be led to positions where the men working them will be clear of danger should the spars collapse or fall over.

Sheers and derricks should not be heeled beyond an angle of 20 degrees with the vertical unless the topping lift or back guy is particularly strong and secure and makes an angle with the head of at least 70 degrees when the spar(s) are heeled.

One hand should be detailed to watch each guy—or, if using the gear ashore, each holdfast—when hoisting or lowering a load. If the topping lift or back guy holdfast starts to shift from its bed, lower the load and at the same time haul it towards the foot; this will ease the stress in the topping lift or back guy.

All tackles should be worked as smoothly as possible. If, after hoisting, a load has to be left suspended, the fall should be eased back slightly to equalise the stresses between its running parts.

When a load is lowered with the derrick or sheers nearly vertical, unless the topping lift or back guy is checked as the load nears the deck, its weight will tend to haul the derrick or sheers over backwards when the load touches the deck.

When hoisting a load the derrick or sheers should never be topped up while the main tackle is being worked, because this puts excessive stresses on the derrick or sheers.

It cannot be emphasised too strongly that the safe working load of extempore gear is governed by the lowest safe working load of the individual rope, block, fitting or spar.

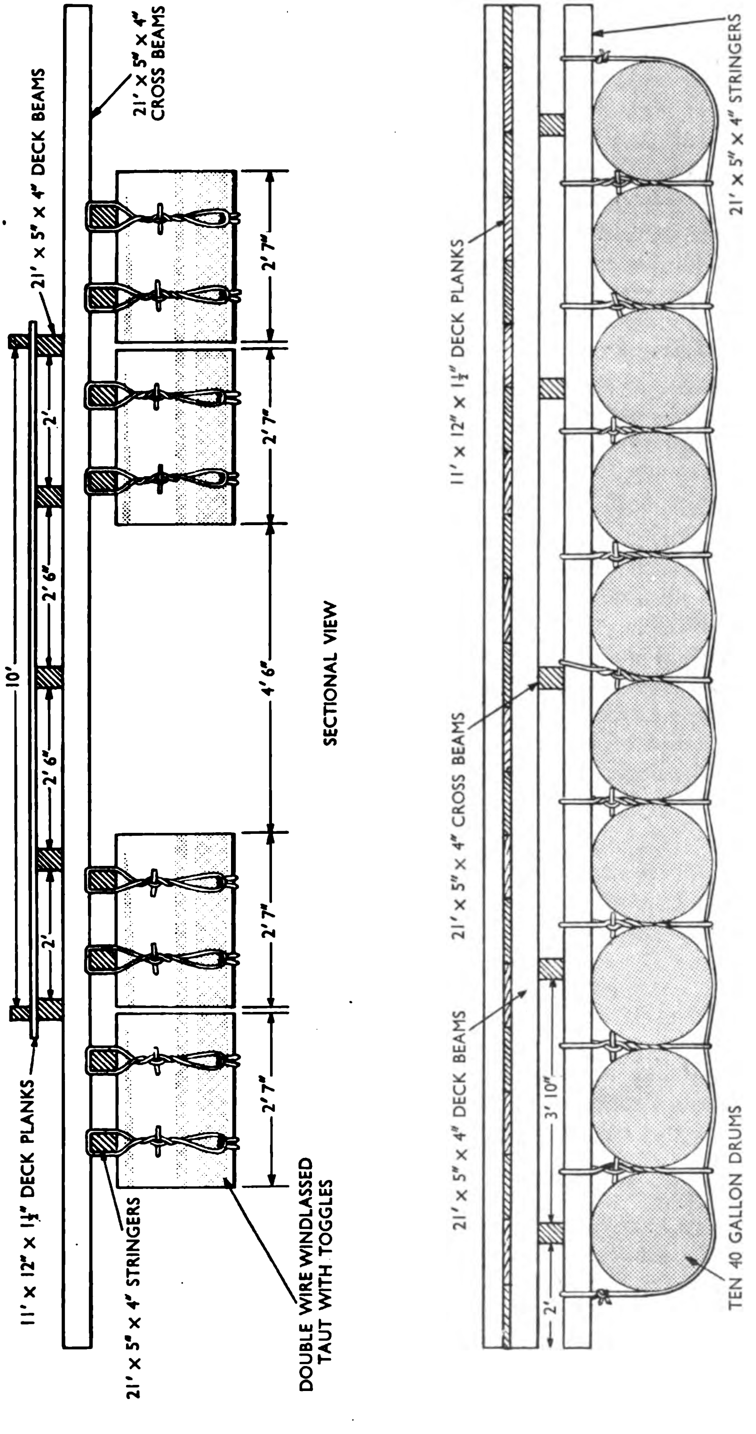


FIG. 6–43. Timber and drum raft

RAFTS

There may be times when a seaman is required to transport gear or stores by water from one place to another and he may find that the ship's boats have not the capacity or buoyancy for the task. He must then construct a raft, unless the gear is buoyant and can, therefore, be floated ashore. One type of raft is described below, but it must always be remembered that, when constructing a raft for a particular purpose, much will depend on the materials available and the ingenuity of the seaman on the spot.

Formulae for finding the buoyancy of a spar and of a drum are given in Appendix I (page 606).

Timber and drum raft

A raft capable of carrying a loaded 30-cwt lorry (total weight, $4\frac{1}{2}$ tons) is illustrated in fig. 6–43. It is constructed of eighteen 21-ft scantlings of 5 in. × 4 in. timber, twenty-one planks each 11 ft × 12 in. × $1\frac{1}{2}$ in., and forty 40-gallon drums.

The eight stringers are laid 1 ft apart in two sets of four, with a distance between the sets of 5 ft. The drums, with their bungs uppermost, are lashed in pairs below each set of stringers, the lashings being tautened by toggles, as shown in the illustration. The five crossbeams are lashed or bolted across the tops of the stringers 3 ft 10 in. apart. The five deck-beams are lashed or bolted across the tops of the crossbeams, the inner ones being 2 ft 6 in. apart and the outer ones 2 ft from the inner ones. The twenty-one planks are nailed across the deck-beams to form a deck 21 ft long and 10 ft wide, and 2 in. × 3 in. scantling is nailed on the top of the ends of the planks to form a footrail on each side of the deck.

CHAPTER 7

Sailmaking and Awnings

Sailmaking in the Navy is a trade which covers far more than the name implies. Originally the sailmaker made and repaired the sails of the ship and her boats; now he provides and maintains the sails of boats and a multitude of other gear made of canvas or one of its modern counterparts manufactured from man-made fibre, including awnings, screens and covers, all of which are designed to protect what is underneath. Today all the 'canvas' gear in a ship should be supplied by the Dockyard sail lofts, and the task on board is reduced to one of maintaining and repairing it. Therefore the Navy Department has decided that the Sailmaker Branch should be allowed to die out and that the comparatively unskilled work of repair and maintenance should be taken over as a normal part of a seaman's trade. However, many of the items of canvas gear in a ship are simple to make, and many seamen in small ships without sailmakers already do those jobs. Given the basic knowledge and the right equipment, a seaman can, with interest and practice, renew and repair canvas gear when a ship cannot wait for the next visit to a dockyard.

This chapter describes the material and tools and how a seaman can sew and repair canvas and replace roping, splices and finishings (grommets, cringles, etc.). It also includes sections on sails and awnings. Those interested in the finer points of sailmaking should read B.R. 2176, *Sailmaker's Handbook*.

FABRICS

In the past, fabrics were made from natural fibres, such as flax; but modern developments in the man-made fibre industry have produced materials from which fabrics can be woven which are superior both in strength and durability, their higher cost being offset by their lasting quality.

Flax and hemp canvas

Canvas is a cloth woven from yarns of flax, hemp, and sometimes jute. Royal Navy (R.N.) and Merchant Navy (M.N.) canvas are made of flax, or sometimes of flax and hemp, and they are supplied in rolls 2 or 3 feet wide and 39 yards long, called *bolts*.

The formation of a length of canvas is shown in fig. 7–1. The threads which run across the breadth of the canvas are called the *weft*, and those which run throughout its length and are rove alternately over and under the threads of the weft are called the *warp*. As the weft is continuous and unbroken the canvas does not fray at the *selvedges* (sides of each strip), but it will fray at the ends of each strip and wherever it may be cut; such an edge is known as a *raw edge* and is never permitted in sailmaking, either when sewing canvas or in the completed job. If a raw edge is to be sewn it is first folded over to a depth of

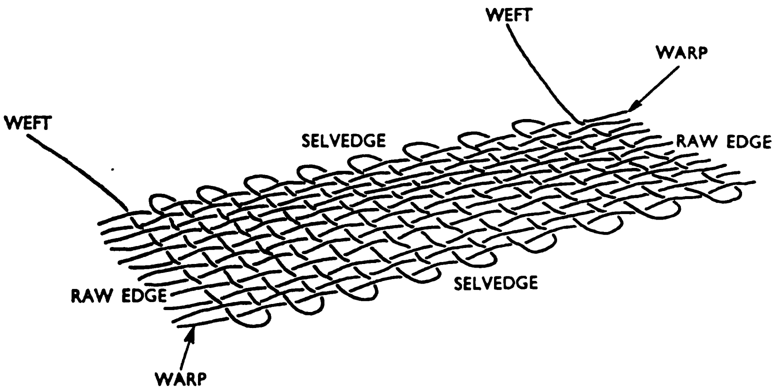


FIG. 7–1. Diagram showing construction of canvas

about half an inch and the stitches are made along this fold, it being then known as a *bight*.

Canvas will stretch to a limited extent lengthways in the direction of the warp, but not appreciably in the direction of the weft, and if a heavy pull is exerted along the warp the breadth of the canvas will be slightly reduced.

When wet the threads themselves shrink, those of the warp shrinking rather more than those of the weft, and they will not resume their original length when dry unless the canvas is again stretched out taut. Allowance is made for the initial stretch in canvas when cutting out a new awning, and shrinkage is also allowed for when making unpainted canvas covers for reels and other fittings. When canvas is painted the paint fills in the spaces between the threads, and when dry it prevents either shrinking or stretching, but as the paint is applied the canvas will shrink slightly. When a very taut screen is required the canvas is laced in place as tautly as possible, then wetted to tauten it still more, and painted whilst still damp.

Canvas for the Royal Navy is manufactured in different weights, No. 1 being the thickest and heaviest and No. 7 the thinnest and lightest, and each grade has a specified breaking strength. The warp is made of flax thread, which is doubled in all but No. 7 canvas. The fibre of the weft can be identified by the colour of the *seam line*, which runs throughout the length of the bolt close within the selvedge—red for hemp, blue for flax. If the canvas is rot-proofed a green seam line is woven into the material. The seam line also serves as a guide to the breadth of the seam when sewing two pieces of canvas together—1½ inches for Nos. 1 and 2 canvas, 1 inch for all other grades, and ¾ inch for cotton duck. All R.N. canvas has a wavy blue line running across the breadth throughout the length of a bolt.

The following are examples of the purposes for which each grade is used:

R.N. No. 1—canvas baths

R.N. No. 2—large awnings

R.N. No. 4—small awnings, weather screens, boat and gun covers

R.N. No. 6—awning curtains and side screens

R.N. No. 7—some boats' sails.

Man-made canvas and fabrics

Raw materials such as coal and petroleum can be converted by chemical processes into fibres suitable for weaving into fabrics such as Nylon and Terylene canvas. Nylon is stronger, more elastic and lighter than Terylene, but its initial resistance to stretching is less. Both are stronger and more elastic than natural fibres and more initially resistant to stretch than cotton.

Both Nylon and Terylene absorb practically no water, and quickly lose what little they do absorb; and for practical purposes they do not shrink when wet. They are both immune from attack from mildew and other organic action, and they are unaffected by oil.

Prolonged exposure to sunlight deteriorates all textile materials. Both Nylon and Terylene have fairly good resistance, depending to some extent on the thickness of the material. The resistance of Nylon can be improved by dyeing.

Only one weight of Nylon fabric is supplied to the Royal Navy (1963), a light blue fabric weighing 1½ ounces per square yard in widths of 32 inches for spinnakers.

Terylene is supplied in three weights, Terylene No. 2 weighing 27 ounces per square yard, Terylene No. 4 weighing 22 ounces per square yard (both 24 inches wide), and an unnumbered fabric weighing 7½ ounces per square yard, in widths of 32 inches, used for making the sails of the 27-foot motor whaler.

Coated fabrics

Nylon, Terylene and natural fabrics can be coated with various substances to produce fabrics which combine the advantages of the base fabric with those of the coating. The principal coatings in use today are Polyvinylchloride (PVC), Neoprene, Hypalon, Polyurethane, other synthetic rubbers, and natural rubber.

Some coated fabrics are in use in the Service today (1965). PVC-coated Nylon 'mock leno' fabric ('mock leno' being the type of weave) is supplied in three colours, grey, white and cream, in bolts of 50 to 60 yards of 36-inch width. It is completely impervious to water and is suitable for all upper deck coverings and boats' canopies. The coating is applied to both sides of the fabric. PVC-coated cotton fabric, called 'PVC leathercloth', is used for upholstery.

Cotton

There are several cotton materials available in the Service.

White drill, a strong twill weave of heavy texture, used mainly for boat's cushion covers, etc.

White duck, a strong plain-weave fabric of canvas type, stronger and heavier than drill, is supplied in bolts of 80 yards, in widths of 18 or 29 inches with a seam line ¾ inch from the selvedge, and used for covers. Duck made from Egyptian cotton is lighter and supplied in widths of 18 inches; it is used for dinghy sails, but is being replaced by man-made fabrics.

Blue jean, a material similar to drill, but lighter; it is supplied in widths of 27 inches and is used for 'tiddly' work.

Black calico and cambric are plain-weave fabrics with a smooth texture and are used mainly for sail markings.

Bunting was until recently a woollen open-weave fabric for making flags,

ceremonial awnings, etc. Today it is made from a mixture of 75 per cent Nylon and 25 per cent wool, spun together.

Jute

Jute yarn is coarser than flax and is normally used for making sacks. The fabric supplied to the Service is hessian and is used for making target sails. It is supplied in two colours, black in a width of 72 inches, and white in a width of 37 inches.

SAILMAKER'S TOOLS

(figs. 7–2 (a) and (b))

Needles. Hand sewing needles are made of cast steel and are triangular in cross-section for about half their length. There are two sizes for sewing canvas and two for sewing boltropes. There are also special needles for sewing flags, upholstery, etc. Machine needles are divided according to their size and the style for the particular machine.

Palms. These are made of leather and hide, shaped to fit over the hand, and designed to protect it. The eye of the needle rests in the metal cup as the needle is forced through the fabric. New palms should be soaked in water until they take up the shape of the hand. The roping palm can be distinguished from the seaming palm by the larger metal cup and hide guard to protect the thumb when hauling the twine in roping stitches.

Rubber. A small steel tool of square cross-section used for rubbing down the stitching, particularly of round seaming, to make it lie flat.

Sail hook. A hook about 4 inches long used to hold the canvas when sewing; it serves as a 'third hand' for the sailmaker. A short length of codline is spliced into the eye of the hook and secured to the head of the sailmaker's bench.

Pricker. Wood-handled steel spike, 3, 5, 8 or 10 inches in length, used for splicing small wires and cordage and for making holes in canvas.

Canvas piercer. Wood-handled fluted steel blade 4 or 6 inches in length, used for making holes in canvas before inserting a brass grommet.

Wad punch. A metal tool for making holes in canvas before inserting a metal grommet.

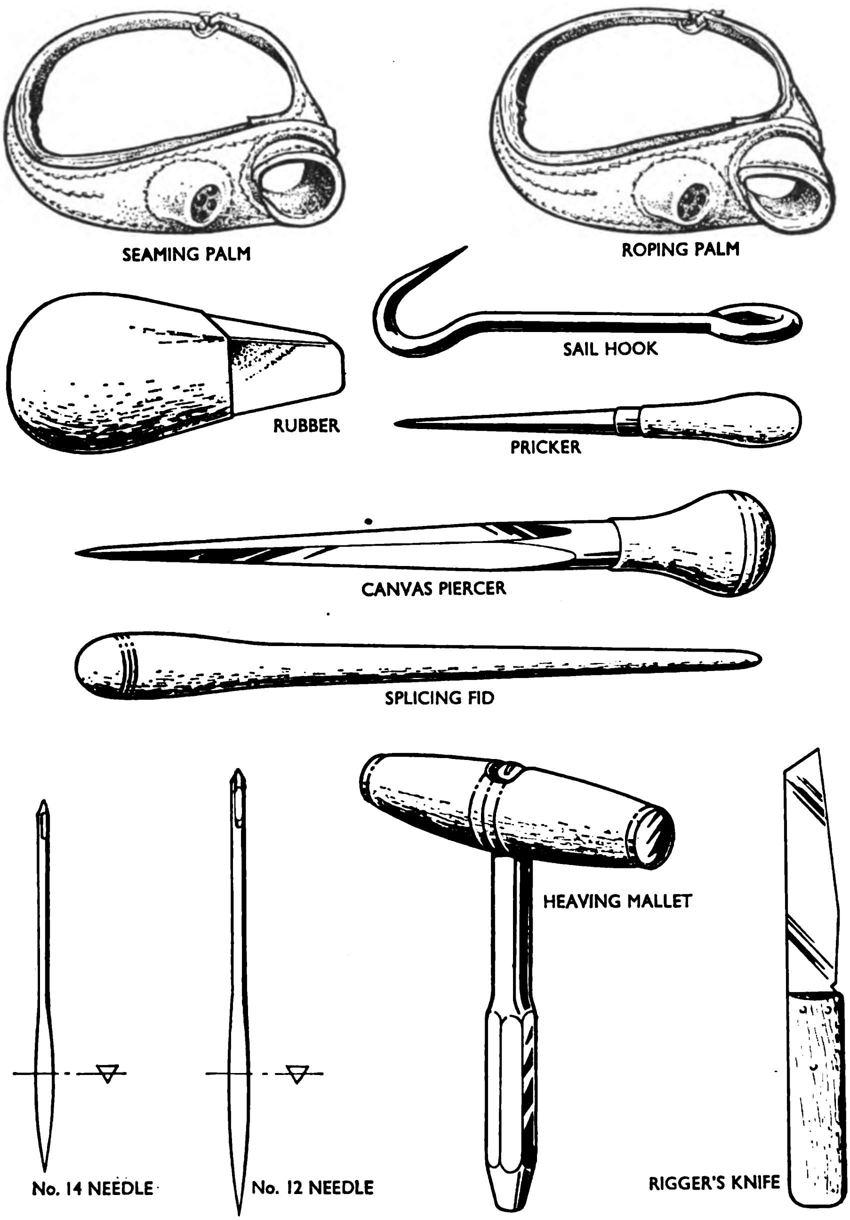
Splicing fid. A tool of tapered hard wood, such as lignum vitae or greenheart, 10, 18, 24 or 30 inches in length, used for splicing fibre ropes and opening out cringles, worked eyes, etc. Larger fids, with their ends reinforced with metal, are used when inserting large heart-shaped thimbles into awnings.

Heaving mallet. There are two types; the one illustrated has a metal shank and is used for hauling in stitches. The other type has a wooden shank for hauling in ends of cordage.

Knife. For cutting canvas—except 'on the gore' (diagonally), when shears should be used. A shoemaker's knife is used for canvas and a rigger's knife for cordage.

Shears. For cutting light materials such as cotton duck, and canvas 'on the gore'. Pinking shears leave a serrated edge to the material cut.

Punches and dies. For inserting brass grommets.



7–2 (a). Sailmaker's tools

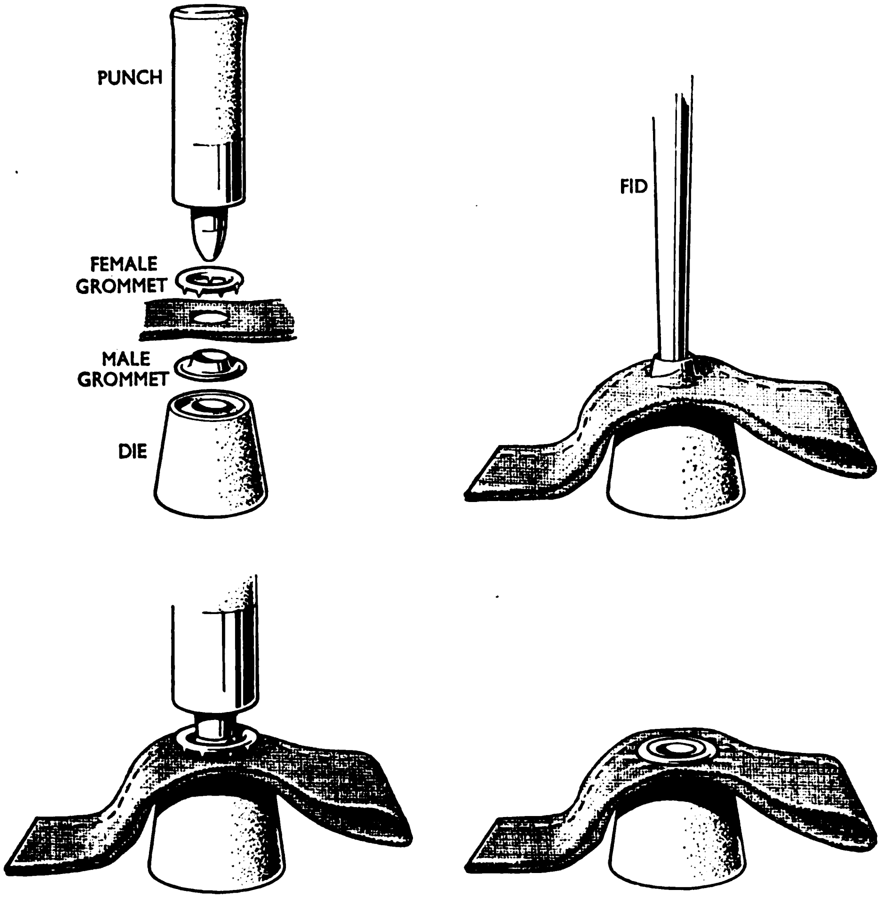


Fig. 7–2 (b). Sailmaker's tools

Knocking-up board (not illustrated). A piece of hard wood with holes of different diameters drilled in it, used for hardening up small grommets.

HOW A SAIL OR AWNING IS MADE

Before describing the separate processes of sailmaking, a brief description will be given of the sequence of work in making a sail or awning.

Because of the narrow width of a bolt of canvas, a sail or awning must be made from a number of lengths sewn together. When this has been done, the straight edges are strengthened by turning back and sewing down a width of material (*tabling*), and the curved edges by sewing on a strip of additional material (*false tabling*); and when there is likely to be a stretching of the edges—for example, in the luff of a mainsail—roping is sewn on one side of the material.

The corners and some places on the edges of a sail or awning are specially strengthened to withstand the additional strains where halyards, sheets, etc., are secured, by sewing on straining patches (*strainers*) or reinforcing patches, usually of the same material. Thimbles are worked into the roping, either with a starting eye (sailmaker's splice) on the corner, or by working the strand of a rope into a cringle round a thimble on the edge.

The finished work must be protected from chafe by *chafing* (or *doubling*) *pieces*, made from the same or from heavier material or from tanned hide, sewn on the side of the material to be protected.

SEWING CANVAS

Sewing can be by two methods, machine or hand. Besides being very much quicker, machines make a closer stitch, with a more even tension in the thread or twine, than hand sewing: on the other hand, certain tasks can only be done by hand because of such circumstances as the shape of the seam to be sewn or the size of the article being sewn; and in any case machines are not at present available in all ships. Conversely, some of the man-made materials, such as mock leno, are best stitched by machine, as hand sewing tears the fabric.

The following paragraphs explain some of the stitches used in hand sewing, but there are certain points which are common to them all.

Before starting to sew, the seaming (or roping) palm should be adjusted so that it fits the hand comfortably. A palm which is too tight or stiff is likely to cause cramp in the hand; this can be prevented by soaking the sewing palm in hot water to make it pliable. When making the stitches, the point of the needle should be held between the forefinger and the thumb, and the middle finger used to guide the eye of the needle to the pellet of the palm each time the needle is pushed through the material. This should be practised without thread in the needle until it is done instinctively.

Stitches should be 'hand taut' (a pull of approximately seven pounds), and each stitch must be as taut as the others. When sewing with twine, it should be well rubbed with beeswax; this helps to preserve the twine, to prevent tangles while sewing, and to lubricate it so that the twine will pass through the canvas more easily.

After using a length of twine, cut if off within an inch of the canvas. Rethread the needle, then start stitching through the hole of the last stitch, laying the short ends of the old twine between the two pieces of canvas, and make the next few stitches over the top of them.

All sewing is finished off by making a back stitch, passing the needle through the holes made by the previous stitch.

When turning in the edge of canvas before sewing a seam, it is necessary to rub down the new edge with a rubber; this keeps the fold in position while sewing. The seam should also be rubbed down after it has been sewn, in order to make it lie flat.

The following paragraphs on flat and round sewing describe the process of joining two pieces of fabric together selvedge to selvedge, with a seam line adjacent to the selvedge. When joining cloths raw edge to raw edge, or when

using fabric without a seam line, it is best to mark in a 'false' seam line to act as a guide.

Some sailmakers refer to the process of joining two cloths side by side (i.e. selvedge to selvedge) as *seaming*, and that of joining them end to end (i.e raw edge to raw edge) as *lasting*, but these terms are not universal.

Flat sewing

This is a simple method of joining two pieces of fabric for use when strength is not particularly required.

Flat seam (fig. 7–3). Place the selvedge of one piece of canvas on to the seam line of the other, hook both pieces of canvas on to a sailmaker's hook, keep the cloths flat on the knee and sew away from the hook, using approximately 120 stitches to the yard (3 to the inch). The needle should pass down through the

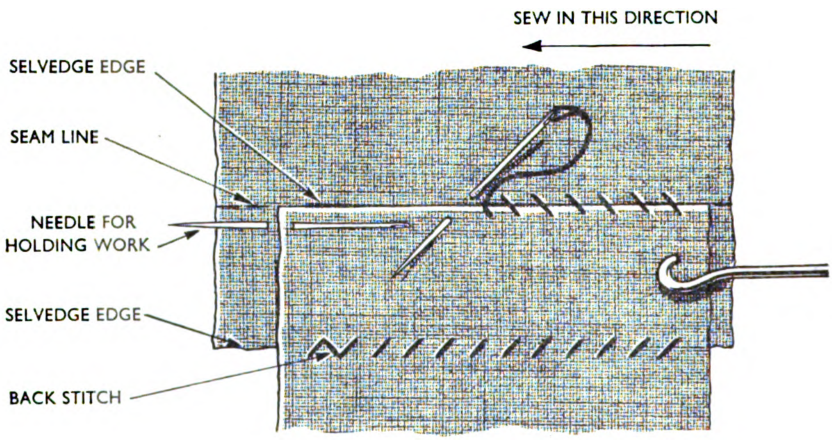


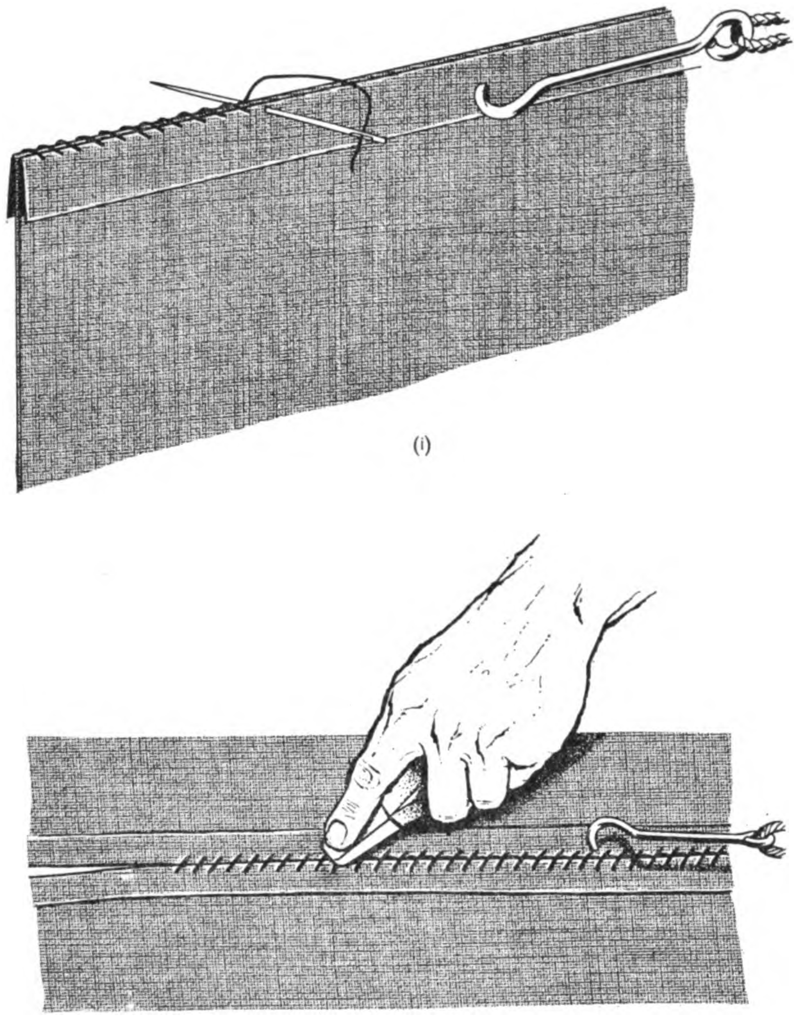
FIG. 7–3. Flat seam

single cloth close to the selvedge and seam line and up through the two cloths to the other side of the selvedge. The job should then be reversed and the other selvedge sewn to the other seam line.

Round sewing

Because the stitches in round sewing pass through more parts of the fabric, as shown below, this gives a stronger joint than flat sewing.

Single last (fig. 7–4). To sew a single last, turn in both cloths at the edge about half an inch and rub down; place the two cloths together with the turned-in edges outwards, fasten both cloths to the sailmaker's hook, start sewing at the end furthest from the hook and work towards it. The stitches should be made by passing the needle through all four parts of the canvas about $\frac{1}{8}$ inch from the edge and back over the top as in the illustration, making three to four stitches to the inch. When finished, open out the two cloths and rub down the seam to flatten it out. This seam can also be sewn with the turned-in edges of the cloths towards each other.



(i)

(ii)

Fig. 7-4. Single last

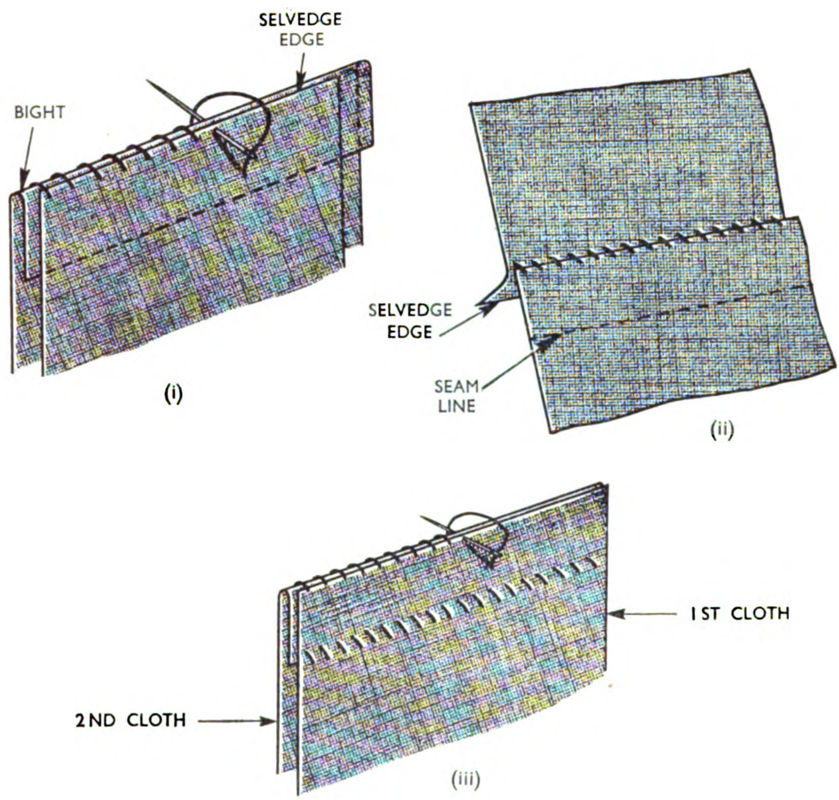


FIG. 7–5. Round seam

Single round seam (fig. 7–5(i)). To sew a round seam, turn in one cloth at the seam line, rub down, and place the rubbed-down edge on the selvedge of the other cloth with the turned-in part towards it. Fasten both cloths to the sail hook, with the unfolded cloth towards you, and sew towards the hook, making approximately four stitches to the inch, the needle passing through all three parts of the material and back over the top. After sewing, open out the cloths and rub down the seam (fig. 7–5(ii)).

Double round seam (also known as a 'double last'). To sew a double round seam, the second cloth (which was unfolded when sewing the single seam) should now be folded at the seam line as in fig. 7–5(iii) and sewn to the selvedge of the first cloth. Rub down after sewing.

Tabling

The hem or turn-in of material along the edges of a cover, awning or sail provides an additional thickness of material for strengthening and is called a 'tabling'. The material is turned over for a width of two or three inches, and the inner edge is turned down ¼ inch and sewn with flat seaming (fig. 7–6).

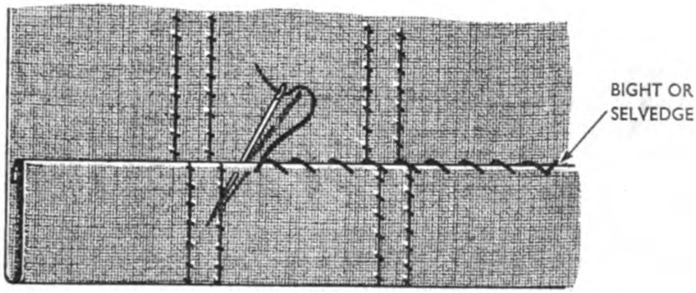


FIG. 7–6. Tabling

False tabling

This is used where there is a considerable curve along the edge of the work, such as the edge of a sail, and is made as follows: A curved line is marked along the edge of the work at a distance from the raw edge equal to the width of the finished tabling plus $\frac{3}{4}$ to $1\frac{1}{2}$ inches. A strip of material is now cut off $\frac{1}{4}$ inch *outside* this line (fig. 7–7(i)). The cut edge and the raw edges of the strip are now turned down $\frac{1}{2}$ inch, as shown in fig. 7–7(ii), and the strip is tacked in position before sewing so that the seams of the tabling are to one side of, and parallel to, those of the body cloths. This makes a neater finish and lessens the thickness of material to be sewn if the edge has to be roped.

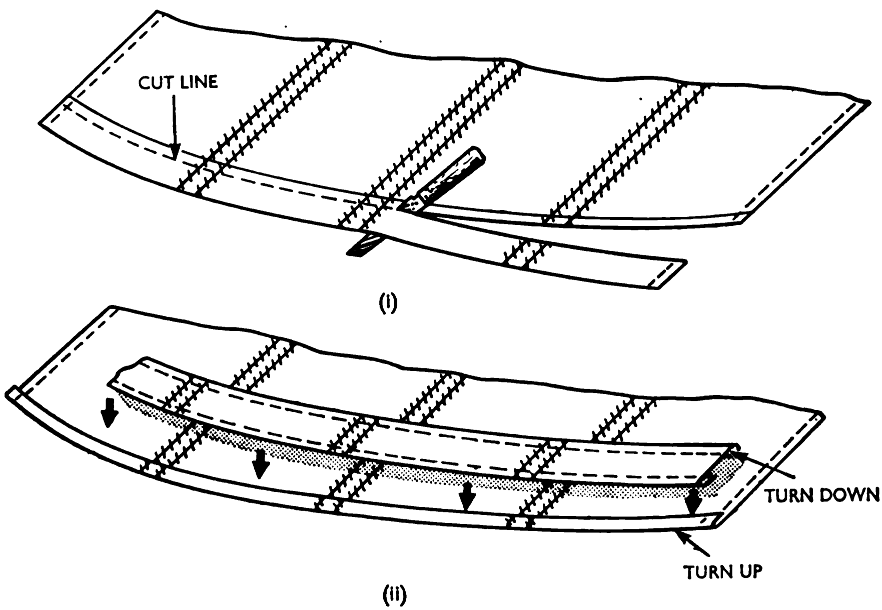


FIG. 7–7. False tabling

REPAIRING CANVAS

Damage to canvas is likely to be in the form of a tear or a hole. If a hole is very large, extending over half the width of a cloth, it will be advisable to replace the whole width of the cloth.

Patching

A piece of canvas of the same grade as the parent material is cut to a size which, when laid over the hole, extends two or three inches beyond the limits of the hole in all directions. Lay the patch over the hole so that the warp threads run in the same direction as those of the canvas being repaired, then put a small stitch in each corner to hold the patch in position (fig. 7–8(i)). Turn in ½ inch on all sides of the patch, mitring the corners, and sew the patch on to the canvas with a flat seam, taking care to secure the corners properly. If one edge of the patch is selvedge there is no need to turn it in (fig. 7–8(ii)).

The work is then turned over and the edges of the hole are trimmed with a knife so as to leave a strip 1½ inches wide (2 inches in No. 2 canvas) all round inside the line of stitching (fig. 7–8(iii)). Cut the corners so that ½ inch of the strip can be turned in and sewn down with a flat seam (fig. 7–8(iv)). If the hole

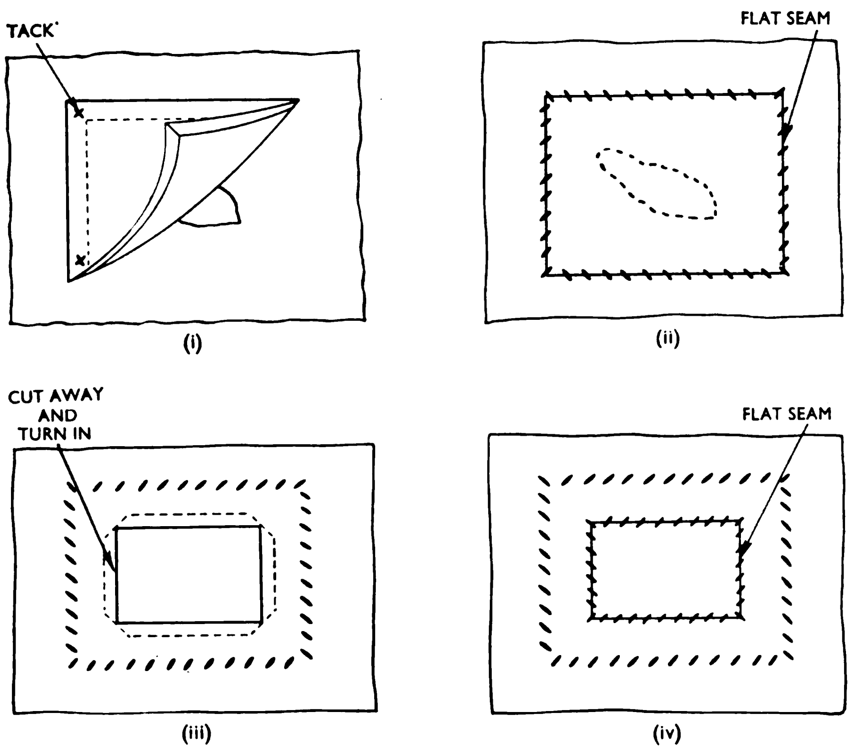


FIG. 7–8. Patching

is near a tabling, the sewing holding the tabling can be cut and the patch slipped underneath it.

Darning

Darning is used for sewing small tears, and is done as follows: The canvas is held so that the tear points directly at the sailmaker. The first stitch is made by bringing the needle up through the canvas just to the left of the end of the tear, then down through the canvas on the right side and up through the tear, and then through the bight of the twine so formed (fig. 7–9). Subsequent

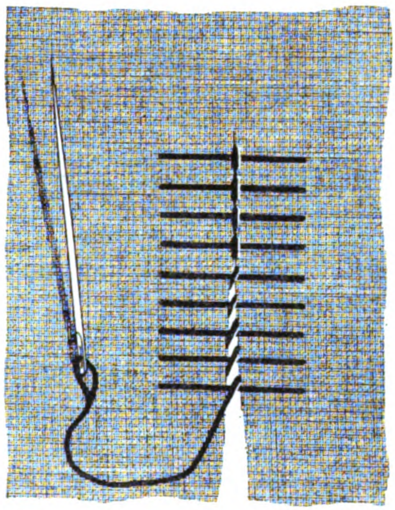


FIG. 7–9. Sailmaker's darn

stitches are made by passing the needle down through the tear, up through the canvas on the left side, down through the canvas on the right side, leaving a small bight in the twine, then up through the tear and the bight. Each stitch is drawn taut as it is finished, and the darn consists of a series of locked stitches sewn closely together. A cornered rent is sewn in exactly the same way.

ROPING

Roping is sewn to certain edges of sails and awnings to strengthen the edge and to provide support for cringles, which in a large awning have to bear a considerable strain. Boltrope, which is soft-laid and stretches less than other rope, is used for this purpose.

Roping is a difficult art and requires many years of practice; but the seaman should be able to do some of the roping tasks, such as replacing worn roping of sails and awnings.

The roping palm is of heavier construction than the seaming palm and is provided with a hide thumbguard round which the twine is hitched when hauling taut. As for ordinary sewing, the needle is kept down on the palm iron (button) with the second figure. Each stitch should be of even depth (about

half the diameter of the rope), and should be hauled taut so that it lies snugly in the grooves of the rope. Four or more parts of twine must be used, according to the size of rope, and the needle must be selected accordingly.

Tatching

This is used for holding canvas together temporarily before roping, and is similar to tacking in clothes-making. The stitches of fine twine are made at intervals of about 1½ inches and will be covered eventually by the roping.

Keeping straight

New boltrope should first be stretched and the turns taken out of it. Then a line should be chalked along the top of the rope as a guide for sewing to the bight of the tabling of the sail or awning.

Regulating slack

Along some edges of a sail the roping stretches more than the canvas, particularly when the roping has been renewed. This is allowed for by leaving sufficient slack in the canvas when sewing the rope to it. The needle is first passed through the rope and then through the canvas. If the needle is passed squarely through both rope and canvas there will be no slack; if the needle is inclined to the right, a small amount of extra canvas is drawn in by each stitch and forms in small wrinkles on the top surface. The amount of extra canvas can be regulated by the fingers of the left hand. By marking both rope and material at intervals of 3 ft the slack can be spread evenly along the boltrope. Certain parts of a sail—for example, the lower few feet of the head of a 27-ft Montague whaler's mainsail—set better if sewn with some slack in the rope, and this is effected by inclining the needle to the left.

The same principles apply in sewing Nylon or Terylene sails to Nylon or Terylene boltrope.

SPLICING

Sailmaker's splices require above all to be compact, and to attain this some strength has to be sacrificed.

Starting eye (sailmaker's splice)

This splice will be found at the tack of a whaler's mainsail; it is made as follows: The first series of tucks are made as for an eye splice. In the second, strand *A* is tucked once with the lay, strand *B* twice with lay, and strand *C* three times with the lay. The object of this form of splicing is to bring all the strands out on the same side of the rope, besides keeping the splice compact (fig. 7–10(i)). To finish the splice strand *B* is halved and each half is seized to strands *A* and *C*, and the two resulting ends cut off. It is sometimes called a 'sailmaker's splice' and the finished eye has a thimble inserted (fig. 7–10(ii)).

Confined tapered splice

This type of splice is used to join two ropes of unequal size, for example, the

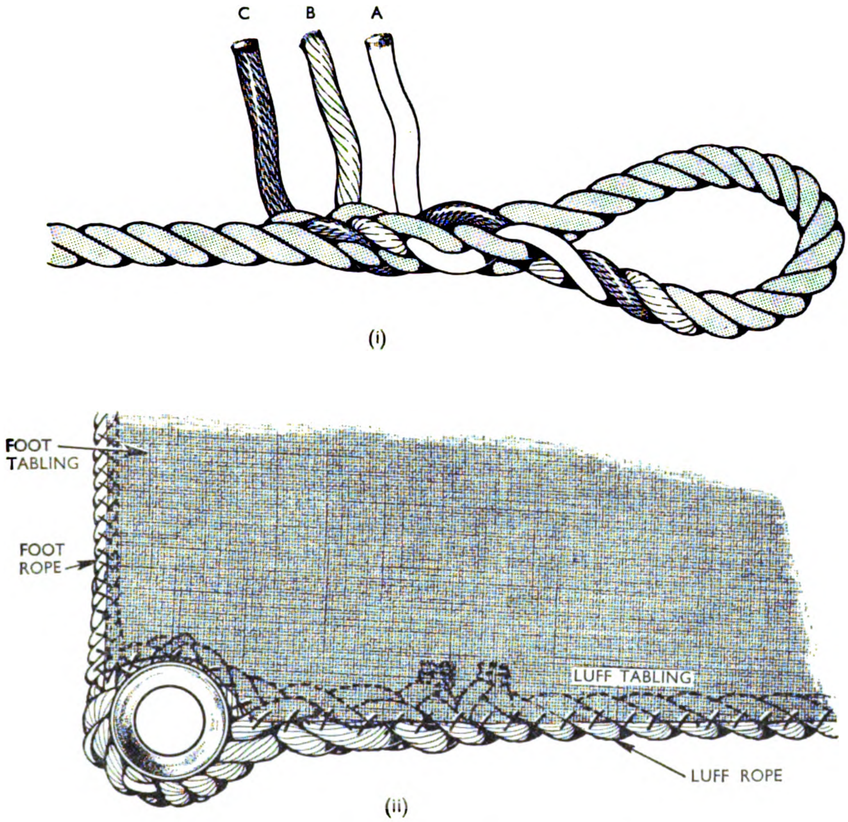


FIG. 7–10. Starting eye (sailmaker's splice)

head and luff ropes of the mainsail of a Montague whaler.

Unlay the large and small ropes for a distance equal to 10 and 8 times their circumferences respectively. Whip all the ends, marry and put on a strong seizing at the marry. Take each strand of the *smaller* rope and tuck it twice against the lay. Pass each strand of the *larger* rope over the adjacent strand of the smaller rope and back under the same strand, i.e. with the lay. Pull tight, and round up the splice between the hands.

Continue to work on the larger rope, reducing one or two yarns before each tucking with the lay and removing those yarns that are underneath the strand when tightened up so that the cut ends are out of sight. The finished splice is shown in fig. 7–11.

FIG. 7–11. Confined tapered splice

RAT'S TAIL

To finish off the roping along certain edges of a sail, the rope is tapered to a point before sewing. Apart from the smarter appearance, this prevents the rope from catching on projections when the sail is in service.

First whip the rope where the tapering is to start, then unlay the strands to the whipping. Unlay each strand and taper each yarn, or pair of yarns, by scraping gently with a knife. Each tapered yarn must now be waxed and laid up, the whole waxed and tapered strand being then relaid in the rope. The other two strands are treated in the same way. (See fig. 7–12.)

When completed, the whipping is cut and the tapered rope sewn to the sail, finishing off with a short seizing at the point.

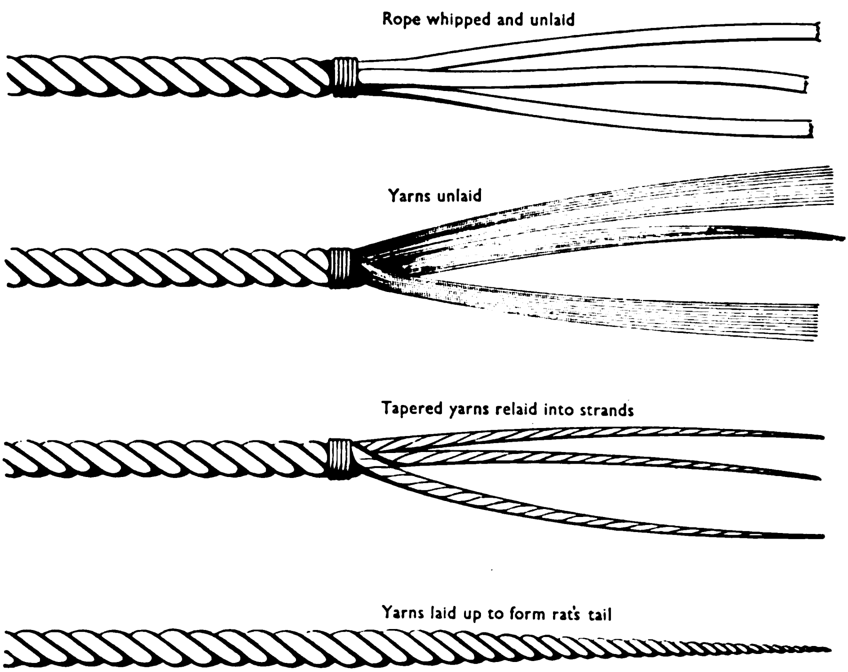


FIG. 7–12. Rat's tail

GROMMETS AND CRINGLES

Grommets

If a hole were cut into material and used without strengthening, the material would quickly tear; so it is strengthened with a grommet of metal or rope.

Metal grommets (fig. 7–2(b)) are normally made of brass in two halves. A hole

is first made in the material with a piercer or wad punch. The appropriate die, the male half of the grommet, the hole in the material, and the female half are aligned with a small fid. The punch is then hammered down so that the female half splays out and jams the material between the two halves.

Rope grommets are made from a single strand of rope (see Vol. I). To 'work an eye', place the grommet on the material, mark the inside circumference and pierce the centre of the circle. Sew the grommet to the material on the same side as any roping, passing the needle down through the grommet and material and up through the hole until the grommet is well covered by the twine.

Cringles

Cringles are described by the number of lays of rope strand laid up round the thimble, i.e. an 'eight-part' or 'six-part' cringle. For awnings an eight-part cringle is used, and is made as follows: A pair of grommets is worked into the awning at the required positions. The canvas is held with the roping facing the sailmaker, then a strand of rope of the required size and length is passed through the left-hand grommet so that the nearer part is about one-third longer than the other part. The two parts are laid up right-handed with four half-turns, bringing the long end out through the right-hand grommet towards the sailmaker (fig. 7–13(ii)). The long end is now laid up in the spaces in the bight of the cringle already formed to make the third strand and a total of eight lays (fig. 7–13(iii)), and on reaching the left side is passed through the grommet towards the sailmaker. The short end is passed through the right grommet away from the sailmaker (fig. 7–13(iv)). Both ends are now tucked into the cringle towards the crown, passing under two parts, and then over one and under two as shown in fig. 7–13(v), so that they finally cross in the crown.

The cringle is now ready for fidding up to insert the thimble. The cringle is placed over a large fid with the roping uppermost, and the work, protected by an old piece of canvas, is beaten down on to the fid. The fid is reversed and the cringle knocked away. The score of the thimble is quickly inserted in the crown (fig. 7–13(vi)) and forced into place by a sharp tap with a mallet before the cringle has time to recover from its stretching. Haul in the strands at the crown and cut them off.

The length of strand required for this cringle is obtained by counting 52 lays of the size of rope required, cutting the rope and unlaying it. Thimbles are chosen from the following table:

Size of rope from which strand is taken (inches)	*Thimble Pattern No.*
$1\frac{1}{2}$	650
$1\frac{3}{4}$	651
2	652
$2\frac{1}{2}$	653

Cringles in boats' sails. The cringles at the reefing points of boats' sails are worked in small hemp line, the smaller thimbles taking a six-part cringle.

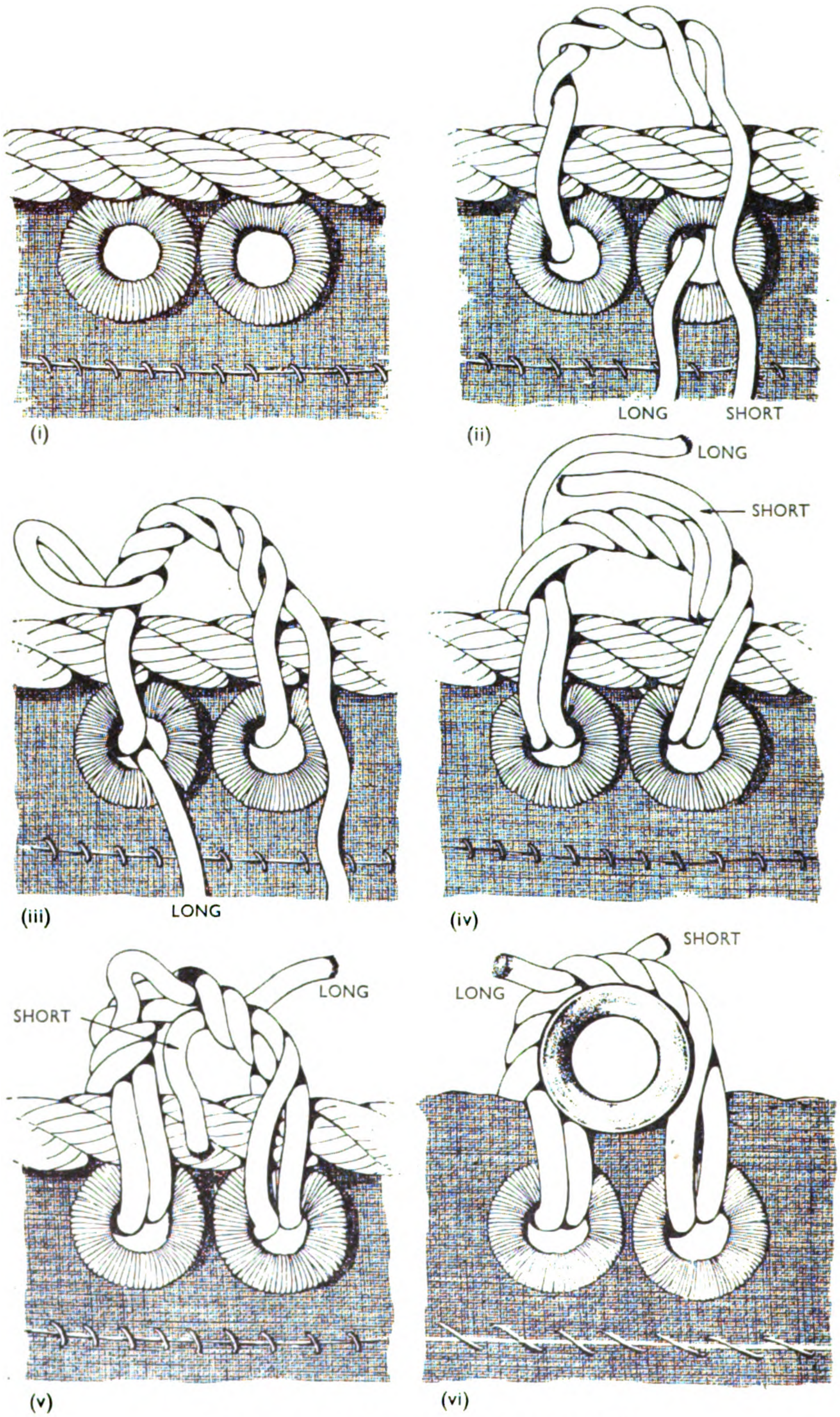


FIG. 7–13. Making an eight-part cringle

SAILS

Names of parts of sails (fig. 7–14)

Fore-and-aft sails. The parts of these sails can be divided into edges and corners and bunt, as follows:

EDGES		
	Head	the upper edge of a four-sided sail
	Leach	the after edge (sometimes spelt 'leech', which is a corruption of 'lee edge')
	Luff	the forward edge
	Foot	the lower edge
	Roach	the curve in the leach or foot
CORNERS		
	Peak	the upper after corner of a four-sided sail
	Head	the upper corner of a triangular sail (sometimes called 'peak')
	Clew	the lower after corner
	Tack	the lower forward corner, i.e. the angle between the foot and the luff
	Throat	the upper forward corner of a four-sided sail
BUNT		the baggy part of a sail.

Spinnakers. The other main category of sail, the square sail, is not discussed here; but there is the spinnaker, which is not, strictly speaking, in either category. The sides are called 'leaches' and the lower corners 'clews'. The point of attachment of the spinnaker boom is sometimes called the 'tack'. The top corner is the 'head'.

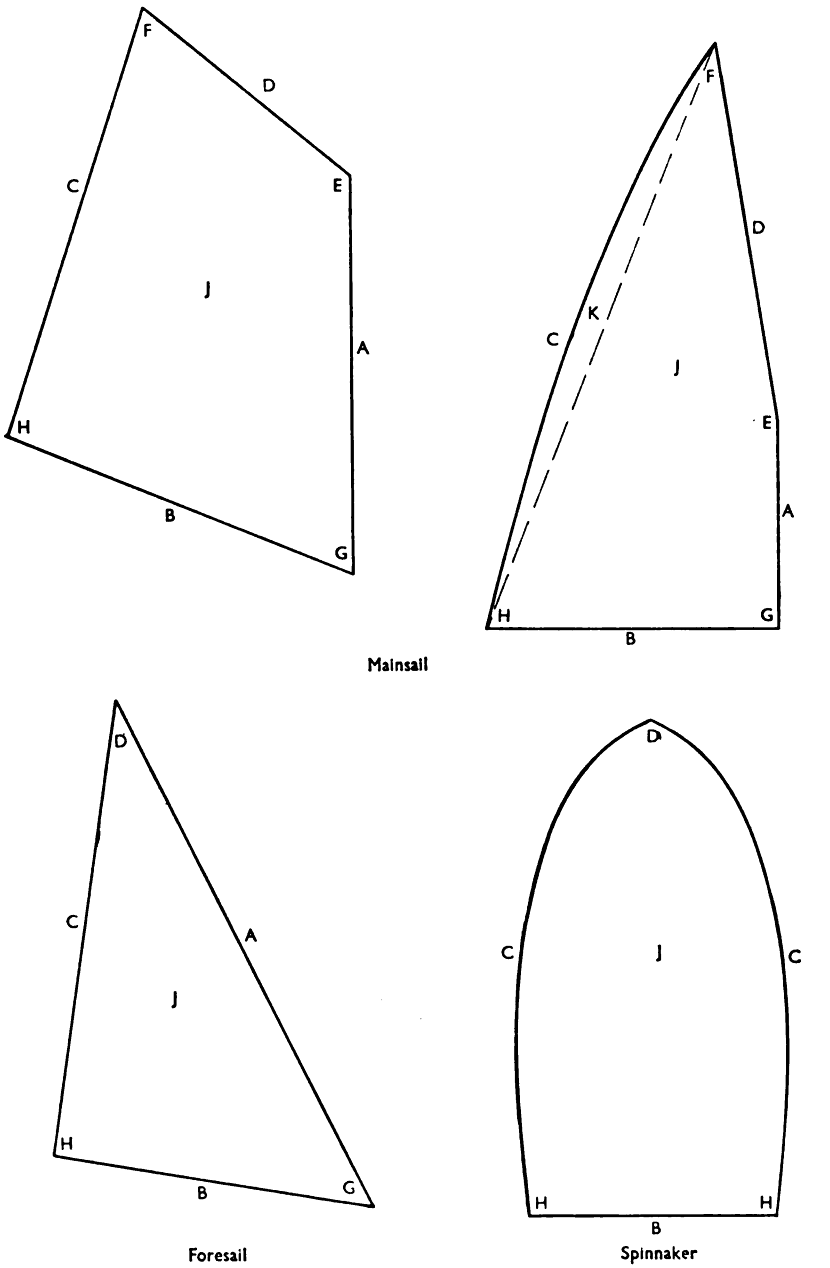
Cut of sails

The manner in which the cloths of a sail are seamed together is called the 'cut' of a sail and has a great effect upon its performance. Four methods are given here and illustrated in fig. 7–15.

Vertical cut is the oldest method of construction, with the cloths running parallel with the leach. It is used with lug or gaff mainsails where the stretch of the comparatively short leach is acceptable, and the additional strength where the sail normally tends to split from leach inwards towards the centre is an advantage. The disadvantage of the cut lies in the wind resistance of the series of ridges of the seams.

Cross or horizontal cut, where the body cloths are set at right-angles to the leach, is used for the mainsails of motor whalers and modern yachts, especially Bermudian-rigged boats where there is a long leach and the leach stretch of the vertical cut would be excessive.

Diagonal or *mitre cut* divides the sail into two distinct sections by a seam (or last) running from the clew to the luff and dividing the angle between the leach and the foot. Above the seam the cloths run nearly at right-angles to the leach; below the seam they run at right-angles to the foot. This cut is used mainly for headsails, where the unroped luff and foot are less liable to stretch, and thus these sails retain their shape very well.



A LUFF B FOOT C LEACH D HEAD E THROAT

F PEAK G TACK H CLEW J BUNT K ROACH

FIG. 7-14. Parts of a sail

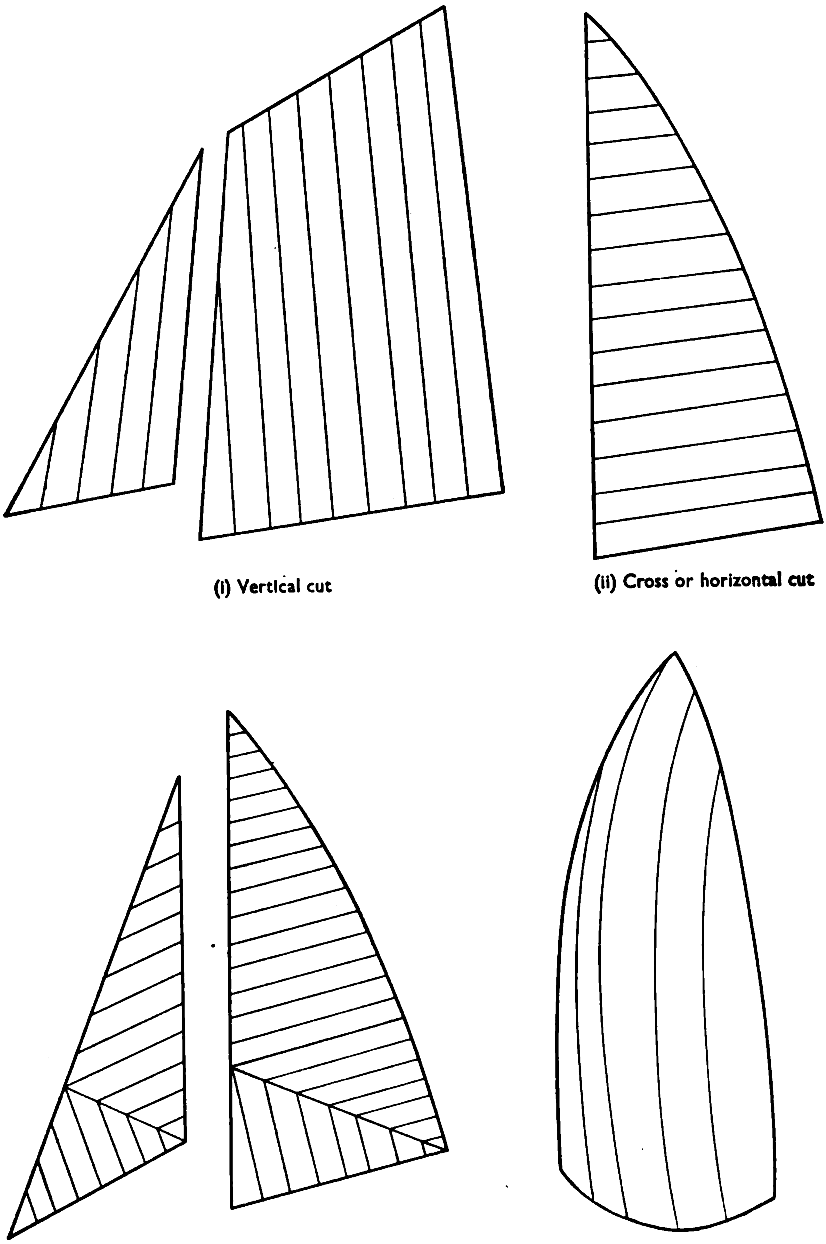
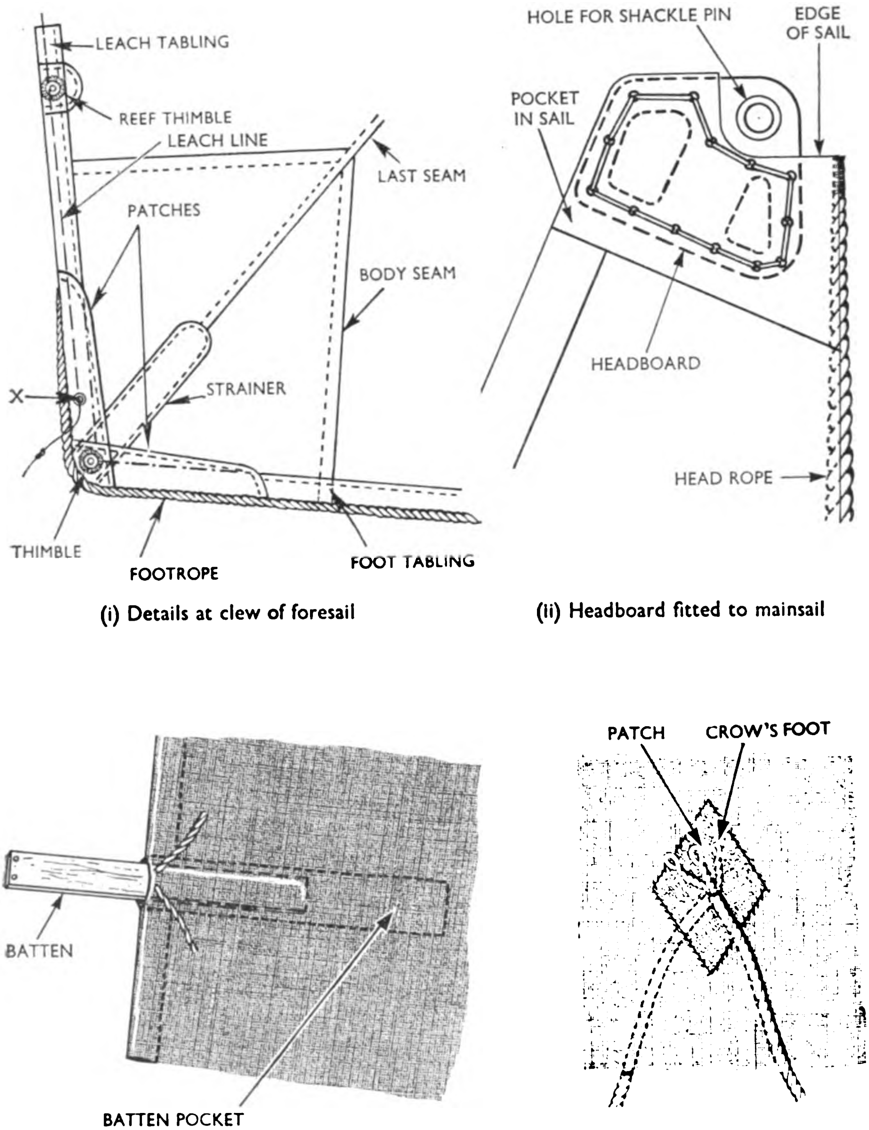


FIG. 7–15. Methods of cutting sails



(i) Details at clew of foresail

(ii) Headboard fitted to mainsail

(iii) Mainsail batten pocket

(iv) Crow's foot in reef point

FIG. 7–16. Details of sail construction

Spinnaker cuts. In Service boats they are cut with the seams running vertically from the foot towards the head. In private yachts many spinnakers are cut horizontally.

Constructional details

After the body of a sail has been cut out and sewn together, the edges are tabled and false tabled, as already described. Strengthening patches and bands

are sewn on, and the sail is roped and cringled. An example of the work required on the clew of a foresail is given in fig. 7–16(i).

Leach line (fig. 7–16(i)). This is a thin line running down inside the leach tabling of a foresail or mainsail, emerging at an eyelet (X) and ending in an overhand knot. If the leach shows any tendency to shake, the leach line is hauled taut sufficiently to stop it, then pulled in a little more and made fast. At all other times the line should be left absolutely slack, and not even made fast.

Headboard (fig. 7–16(ii)). Fitted to the mainsail of a motor whaler, most yacht mainsails and some spinnakers, it reinforces the head of the sail and helps to preserve its shape. The board (of aluminium alloy) is fastened in a pocket formed in the sail material and is drilled to take the halyard shackle pin.

Battens (fig. 7–16(iii)). Hickory or plastic battens are fitted in the roach of most triangular mainsails to maintain the shape of the sail. The pockets are made at least one inch longer than the battens, the lowest being parallel with the foot of the sail and the remainder at right-angles to the leach. The battens are secured with two short pendants through the eyes in their ends. If made of wood, they must be kept varnished to prevent warping.

Luff wires. Some sails have a wire luff rope inside the tabling. The luff can then be set up taut without fear of stretching the sail.

Reef points (fig. 7–16(iv)). Points are cut to the required length and both ends whipped. A crow's foot is then formed in the middle and is sewn to the starboard side of the sail (on a seam, if possible), after one end has been drawn through the sail.

AWNINGS

Awnings are fitted over exposed decks, bridges and living spaces to give protection from the sun. They are carefully measured and cut by the sailmakers to fit the positions where they are to be spread. Side curtains and gable ends are provided to screen and shelter the areas below large awnings, such as quarterdeck awnings; and side screens are supplied to protect selected areas of the ship's side from the sun in hot weather.

Awnings, curtains, screens and gable ends are manufactured from either Terylene canvas coated with silicone resin, or flax canvas proofed with pentachlorophenyl laurate (L.P.C.P.), applied to the yarn before weaving and identified by a green seam line.

Areas covered

Awnings are supplied to H.M. ships on the following basis:

Aircraft carriers—gun sponsons and open command positions on the island.

Cruisers—forecastle deck, extending each side of the bridge as far aft as practicable; quarterdeck, extending each side of the after superstructure as far forward as practicable; the waist wherever there is a sufficiently clear space; the bridge (where open); signal deck and 'B' and 'X' gun decks. Typical arrangements are shown in fig. 7–17.

Depot ships—forecastle deck, quarterdeck, well deck, bridge (where open) and abreast deck houses and funnel casings.

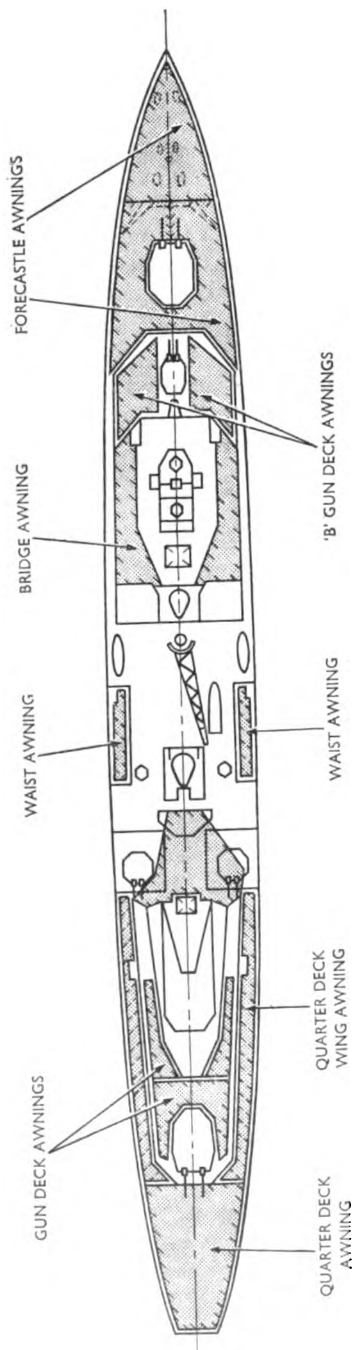


Fig. 7–17. Typical awning arrangements of a cruiser

Destroyers and frigates—as for cruisers.

L.S.T.s and L.C.T.s—upper deck in the vicinity of accommodation, bridge and over vehicle stowage.

TYPES OF AWNING

In general there are two types of awning; the major awning, which is supported by a central wire called the 'ridge rope' or *backbone* and hauled out at the edges to awning stanchions by awning tackles and earings; and the minor awning, which is laced to a wire rope passing through the tops of the surrounding stanchions, called the *edge rope*. Technically, a backbone is a ridge rope sewn into the awning, but it is now seldom found and the separated ridge rope will be called the 'backbone' in this chapter.

Major awnings

Quarterdeck and forecastle awnings, classified as major awnings, are made of R.N. No. 2 flax or Terylene canvas for cruisers, and R.N. No. 4 flax or Terylene canvas for destroyers and frigates. These awnings are supported by a backbone of canvassed F.S.W.R. shackled to an eyeplate or special stanchion at the midship end and secured by bottle-screw and slip at the jackstaff or ensign staff. The edges are hauled out to awning stanchions and the edge rope. The description which follows is of a quarterdeck awning and its support. (A forecastle awning is in every way similar except that the awning is shaped to fit, and is secured at, the after end and hauled out forward.) The awning is made of cloths running athwartships. It has a wire boltrope, served with spunyarn or nettlestuff and marled with hemp line to its outboard edges; and a cordage boltrope at its forward end. A heart-shaped thimble is fitted to an eye worked into the wire boltrope at the after end, and a large cringle is worked into the cordage boltrope at the centre of the fore edge. Cringles are worked into the outboard edges abreast and between the stanchions where the canvas is strengthened by patches. The centre-line of the awning is strengthened by a 24-inch 'saddle cloth' or 'middle band' sewn under the awning to take the chafe of the backbone, and hide patches are sewn on where there is additional chafe from the screw slip, centre stanchions or structural corners. A curtain line of hemp line is attached at intervals on the underside of the awning, close to the outboard edges, to which the top of the side curtain is secured. Furling stops for securing the awning when it has been rolled before stowage, are sewn on top of the awning at alternate seams. Where an inboard edge is attached to the ship's structure, it is fitted with 'S' hooks moused into brass grommets with roping twine.

Securing the awning. The quarterdeck awning is cut to fit at selected points of its fore end, and any stretch is allowed for by cutting the remainder slightly smaller than the area it is designed to cover. Therefore, whenever the awning is spread it must be secured first at its fitted end.

The centre cringle of the fore end is secured by shackle to an eyeplate or special stanchion just above the securing point of the backbone. The other selected points are then secured. A pendant (earing) is shackled to the thimble eye in the wire boltrope at the after end; and a tackle, secured to the ensign

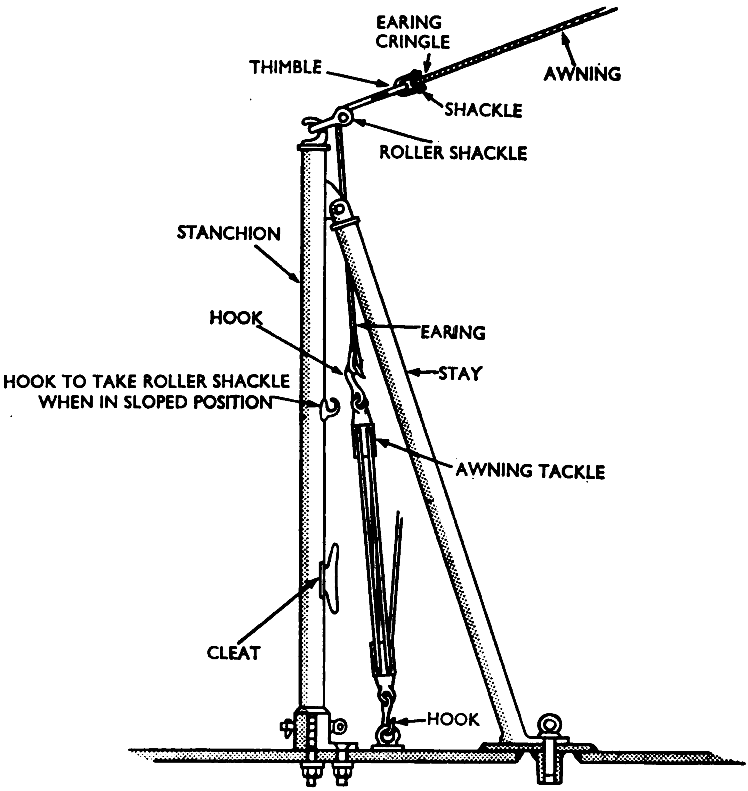


FIG. 7–18. Awning stanchion

staff above the backbone, hauls the awning aft. The sides are then hauled out by the awning tackles (fig. 7–18). Inboard edges are clipped by the 'S' hooks to jack rods welded to the superstructure.

Minor awnings

Waist and bridge awnings are classified as minor awnings. They have boltrope sewn round all edges on the underside to strengthen them and help to retain their shape. Brass grommets, through which the awning is laced to the edge rope, are inserted at regular intervals. Where an inboard edge abuts the ship's structure 'S' hooks clip the awning to a jack rod or wire.

When an awning has to pass round obstructions, such as rigging, davits and fan trunking, a laced opening called a *shark's mouth* or a slotted approach to a hole called a *banjo* is made; if the obstruction is a ladder, portions of the awning are cut away and the edges roped.

When one awning butts against another a canvas flap, called an *apron*, is sewn to one and laced across the gap to a narrow flap, called the *frog* (or *girth*), sewn on the other.

Open bridge awnings are lashed at the corners to brass stanchions and laced

to copper edge-ropes. Thimbles, if required, are of gunmetal. A rafter of Douglas fir sometimes supports the centre line.

Double awnings

Ships serving in very hot climates are sometimes fitted with double awnings, one above the other, to provide an insulating air space in between.

Awning curtains and gable ends

Awning curtains of R.N. No. 6 flax or Terylene canvas are provided to screen and shelter the quarterdeck. They are fitted with grommets for stopping the top to the curtain line, the bottom to screwed eyes in the deck and the sides for lacing to each other. Stops are sewn into them for furling to guardrail height.

The quarterdeck can also be screened by a gable end, of the same material as the curtains, running athwartships. It is stopped to a line sewn across the underside of the awning; the bottom is weighted, and one or two flap entrances are cut in it.

Ceremonial awning

Flagships and certain other ships are supplied with a ceremonial awning and side curtains made from bunting of alternate coloured and white cloths: the colour may be red, blue or green. The awning is spread beneath the main awning on ceremonial and state occasions, dances, etc. The top of the awning is hooked to the backbone and laced out to the curtain line. The side curtains are hooked to the curtain line and laced at the bottom.

Side screens

Side screens, made of R.N. No. 6 canvas, are supplied to certain ships when the sick bay is at the ship's side just below the upper deck and not adequately protected from the sun. The screens are spread from the top guardrail, to which they are laced, to the spiked ends of small booms where they are held by grommet or becket. The booms are heeled with goosenecks fitting into sockets at about deck level, and supported in a horizontal position by a combined topping lift and martingale which is rove from the deck, through a strop hanging from the awning stanchion, over the boom spike (cut splice), through an eye-plate in the ship's side and back to the deck. The foremost boom has a fore guy and the aftermost boom an after guy; the remainder are kept in place by the screen.

To spread a side screen the inner edge is first secured to the guardrail; the booms are then held vertically with their heels shipped in position, and the outer edge of the screen is hooked over the spikes and the martingales are rove; finally the booms are lowered together and all the gear is set up taut. Side screens require careful attention to keep the booms horizontal and square to the ship's side. Fig. 7–19 shows a section through a rigged side screen.

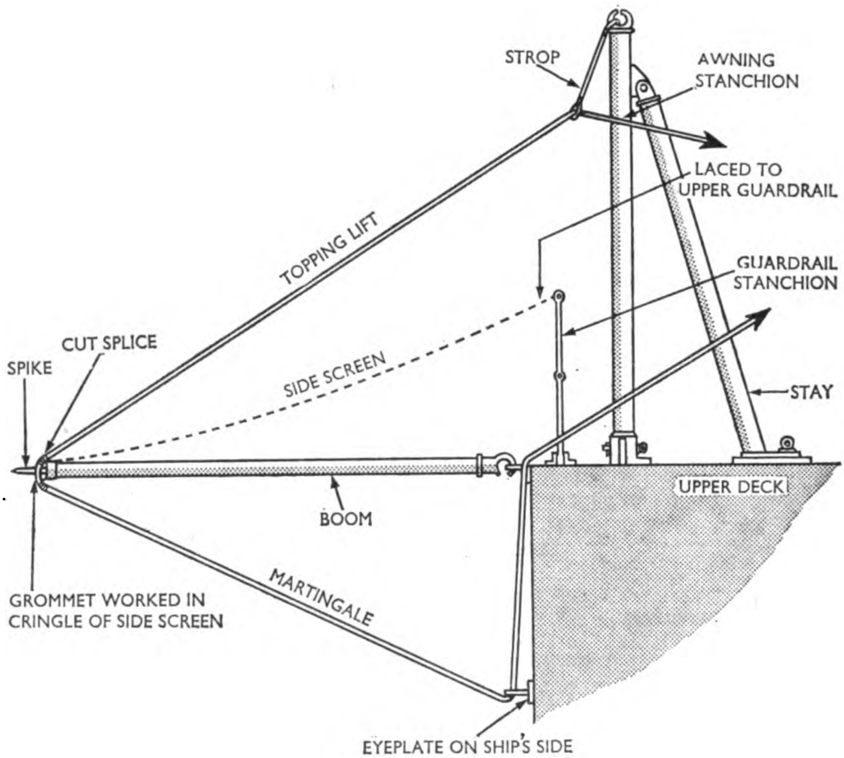


FIG. 7–19. Rigging a side screen

HANDLING AND CARE OF AWNINGS

Spreading awnings

Since the canvas of an awning is subject to stretching and shrinking, every care must be taken to preserve its shape when spread. A baggy, wrinkled or torn awning is usually the result of maltreatment.

A minor awning such as a bridge, wing or waist awning, should first be lashed by the earings on its windward clews, and then unfurled to leeward and its leeward clews secured. The clew earings can then be hauled taut and the sides hooked or laced to the edge ropes or awning rails.

A major awning needs more care, and the method of spreading a quarterdeck awning is given here as a guide; but it is first necessary to know how an awning is folded for stowage. Before stowing an awning it is spread on the deck with its upper side down, and the two sides are then folded to the centre-line and squared off. The two doubled sides are then rolled towards one another to meet at the centre-line and the whole is then secured by the stops fitted along the top of the centre-line. The earings and awning tackles are always detached and stowed separately, but the lacings of a small awning can be made up with it.

When spreading an awning in a cross wind it should always be passed over the backbone from the leeward to the windward side; if passed over from the windward side the pressure of the wind on its sloping surface up to the backbone will make it very difficult to haul it over.

Before spreading a quarterdeck awning it is laid along the deck with its stops uppermost. The stops are then cast off and each side is unrolled, and the boltrope on each side is then hauled clear to the leeward side of the deck. The leeward earings are then secured to their cringles, which are rove slack through their roller shackles and belayed to their cleats. Then hauling-over lines are bent to the windward cringles and passed over the backbone to the other side, where they are manned.

In a high wind the awning tackles on the windward side can be clapped on to the hauling-over lines and used to assist in hauling the awning over the backbone; these tackles are also useful for anchoring the weather edge to the far side and for holding it down while the earings are being secured and rove. Similarly, the leeward awning tackles can be hooked direct to the lee cringles and set up to ensure that the wind does not blow up under the lee side of the awning. It is also usual to rig *tent lines* over the backbone, from the feet of the leeward awning stanchions to the feet of the opposite windward awning stanchions, to support and guide the awning as it is hauled over.

At the order 'Haul over' the awning is hauled over the backbone to the other side and the fore end of the awning is secured to its 'fixed points'. The earings are then shackled on and rove, and the awning tackles are hooked on and manned. The after clew is hauled aft by its earing tackle, thus tautening the centre-line of the awning; then the side earings are hauled out together, care being taken to keep the centre of the awning in line with the backbone. The tackles are then belayed to the cleats and the ends cheesed down at the feet of the stanchions.

Care of spread awnings

A new awning will stretch considerably athwartships but very little in a fore-and-aft direction, and this is allowed for when the awning is first cut to shape. If a good spread is finally to be obtained the stretching must be done gently and gradually. A new awning must therefore never be hauled out or kept too taut until it has been fully stretched, and this stretching must be done by hauling it out a little more each day.

Canvas, like cordage, shrinks when wet, but it should regain its shape when dry if meanwhile it has not been overstretched. A fully stretched awning has little elasticity and may easily be ruined by overstretching when damp or wet. Earings should be eased off in damp weather, and always at night on account of dew. Awnings should not be fully spread until they are dry.

Sloping awnings. When it is raining awnings should be sloped. This is done by shifting the roller shackle of alternate earings to the lower hook (if fitted) and by unshackling the remaining cringles and hooking them directly to their awning tackles by which the awning is bowsed down. This should prevent pools of water from collecting on top of the awning and forcing it out of shape.

Frapping an awning. If caught unawares or short-handed by a sudden squall a major awning should be fully sloped and *frapping lines* rove. These lines, of

strong cordage, are rove athwartships over the awning and belayed at each side on deck so that they help to keep the awning from billowing and slatting. To rig frapping lines overnight as a matter of routine is a slack habit and should be discouraged, because even in light winds their chafe will soon wear holes in the awning. They should be rigged only when a sudden blow is possible, but it is better still to furl the awning overnight. If frapping lines are rigged, hauling-over lines should also be rigged; and tent lines, if used, should be rove and stopped to the heads of the awning stanchions and all gear be prepared for furling.

Furling awnings

A major awning, if well fitted, fairly flat and tautly spread, will stand up to winds of about 5 Beaufort scale, but in stronger winds they are liable to slat badly and may then carry away. Small flat awnings such as bridge awnings should stand up to winds of force 6 quite comfortably. All awnings should be furled well before the danger point is reached, and it is best always to furl them when in doubt rather than have them suddenly blown away.

An awning is usually furled to windward and the procedure is the reverse of that by which it was spread. With a quarterdeck awning, tent lines and hauling-over lines are rigged, earings are eased away squarely and evenly, and the earing tackle at the after end of the centre-line is eased off. The lee earings are unrove and manned; the weather earings are unrove and, if the wind is strong, the weather awning tackles are hooked into the weather cringles and belayed. The after clew is eased forward on its earing; the fore end of the awning is cast off and then, at the order 'Haul over', the lee side is hauled over the backbone. As the lee side is hauled over, the weather side is hauled across the deck to the lee side, so that the awning is eventually laid out underside uppermost and ready for making-up. When furling an awning in a strong wind care must be taken that the wind does not get under the awning and blow it overboard.

In a short-handed ship, when it comes on to blow hard the quarterdeck awning may be safely furled to leeward under frapping lines in the following manner. The awning is fully sloped, with the awning tackles secured to the cringles, and a large tackle is then shackled to the fore weather clew and belayed. The after clew is let go from its earing and gathered, and the awning is passed over progressively from aft forward, each part being gathered as it comes to hand. Eventually all hands are available to hold and gather the windward clew as it is eased over by its tackle.

Maintenance of awnings

An awning—or, for that matter, any canvas gear—should never be stowed below wet, because it will not only rot but may easily catch fire from spontaneous combustion. (The danger from spontaneous combustion is much greater in the case of painted canvas, which for this reason is always stowed in a special store.) A wet awning should be temporarily stowed in a sheltered place on deck until an opportunity occurs for drying it; the quickest way of drying it is to spread it in good weather.

An awning should always be lifted and carried, never dragged along the decks and if it is necessary for it to be laid down on deck, it should be laid on batten,

or gratings in order to keep it clear of the deck and any dirt. As awnings are spoilt by frequent scrubbing, every care should be taken to keep them clean. Decks should be swept before spreading or furling awnings, and when made up they should be stowed where they are protected from dirt and damage. Bags or covers are provided for side screens, gable ends and ceremonial awnings, and they should be stowed in them when not in use.

Terylene awnings

Certain ships stationed in the Far East are fitted with awnings made from Terylene canvas, because this material does not deteriorate in the high temperature and humidity experienced on this station. Their initial cost is high, but they have a much longer life if treated with care. Precautions in the handling and stowage of these awnings are similar to those given in B.R. 2203, *Ship Husbandry Manual*, for flax awnings.

During manufacture these awnings are given a silicone-resin water-repellent finish, and reproofing may be required at some stage of long service. The proofing medium is a thin, colourless liquid which can be applied by brush or non-atomizing, low-pressure spray. One gallon of this material should be applied to every 150 sq. ft of canvas, seams being treated liberally. The solution being inflammable, the awning should be spread flat on a dry day on deck or in a large shed, care being taken to observe the usual fire precautions. Since the solvent is highly volatile, it will soon evaporate, leaving the awning quite dry. If the awning has been cleaned before reproofing, it is essential that all traces of detergent be removed before applying the silicone.

CHAPTER 8

Advanced Boatwork

HANDLING POWER BOATS

Handling a power boat is very different from handling a pulling or sailing boat, because the rotary movement of her propeller (or propellers) exerts a considerable effect on the directive powers of her rudder, not only when she is moving through the water but also when she is stopped or has lost steerage way. The extent to which the steering of a boat is affected by the movement of her propellers depends upon their number and size, the direction in which they revolve, the speed of their revolution, the distance from the rudder and the shape of the boat's hull.

The direction of rotation of a propeller is described as being either right-handed or left-handed; a right-handed propeller is one that turns in a clockwise direction when driving the boat ahead and viewed from astern, and a left-handed propeller is one that turns in a counter-clockwise direction under the same conditions. Most single-screw boats or vessels have right-handed propellers. In general twin-screw Service boats have propellers turning the same way (because standard range engines are fitted to each shaft), but some may have outward-turning propellers (right-handed on the starboard and left-handed on the port side).

The handling of any type of power boat is governed in general by the common sense rules of seamanship, but the method of manoeuvring one boat may differ considerably from that of another owing to differences in the shape of their hulls, the number of their propellers and the type of their rudders. In describing how different types of power boat are handled and manoeuvred, all types of boat will first be considered; then round-bilged boats, including those fitted with a 'Kitchen' rudder; then hard-chine boats.

Use of the rudder

The turning effect of the rudder when the boat is under way increases with an increase in the speed of the boat as well as with an increase in the angle between the rudder and the fore-and-aft line of the boat, and it reaches its maximum value when the latter is about 35°. Beyond 35° the turning effect begins to decrease and the retarding effect of the rudder on the speed of the boat increases rapidly. The rudder angle of a boat is therefore limited to 35° each way.

When the boat turns under the effect of her rudder she turns about a pivoting point which is usually at about one-third of her length from the bows in round-bilge boats, and further forward or aft in hard-chine boats. This pivoting point should be borne in mind when leaving an accommodation ladder or landing-place, because if the rudder is put over to swing the bows outwards the stern may swing in towards the ladder or landing-place and so damage the boat or the ladder.

When turning at speed, particularly if the rudder is put hard over, the boat skids over the water broadside on and outwards as she turns before gathering way in the direction in which her bows are pointing; this is more marked in a shallow-draught or a hard-chine boat than in a deep-draught or a round-bilge boat. As the boat skids the resistance of the water to the hull heels the boat outwards to an angle depending upon the type of boat, her speed and her loading; it will be more marked in a round-bilge than in a hard-chine boat, and in a boat laden with top-weight than in a normally loaded boat. *The rudder should therefore never be used drastically, particularly in boats laden with men or gear, or in a heavy sea, on which occasions the speed of the boat should be reduced before altering course.*

When proceeding at full speed a boat is very sensitive to even a slight touch of wheel, so a large amount of rudder should then only be used in emergency. Except in emergency or at low speed, drastic use of the rudder shows lack of foresight or judgment, and is therefore bad seamanship. When proceeding slowly, however, or when manoeuvring your boat in a confined space, it will often be necessary to use full wheel, i.e. to put the rudder hard over.

The trim of a boat has a great effect on her steering; if she is down by the head or the stern she will be difficult to manoeuvre, and men or weights should therefore be kept distributed evenly amidships as far as possible.

Handling in a seaway

When running before a sea, or when towing, the boat should be trimmed by the stern to keep her propeller immersed and improve her steering qualities. When running before a swell which appears to be moving at the same speed as the boat reduce speed immediately, if necessary by streaming a drogue; otherwise your boat may be carried along on the front of a wave and may broach to and capsize. When running before a quartering sea or swell be on your guard against a wave bearing under the weather counter and so broaching the boat to. When sea or swell are on the bow meet the larger waves head on, and reduce speed as necessary. Alteration of speed in a seaway has a great effect on the behaviour of the boat, so adjust your speed to suit the state of the sea.

Speed

When under way in harbour proceed with due consideration for others. The wash made by a boat at high speed can damage boats alongside ladders or jetties, and cause great inconvenience to small boats and men on painting stages; so reduce speed or give a wide berth in these circumstances, and always keep a good lookout for diving operations.

Going alongside

Accommodation ladder. When going alongside an accommodation ladder in a tideway avoid overshooting and getting the stream on your outer bow; otherwise your boat may be jammed by the stream under the forward side of the ladder and may even be heeled over and swamped. When lying alongside a ladder in a tideway secure the boatrope over the inner bow, and steer the boat so that she rides by the boatrope with her side a foot or so clear of the ladder.

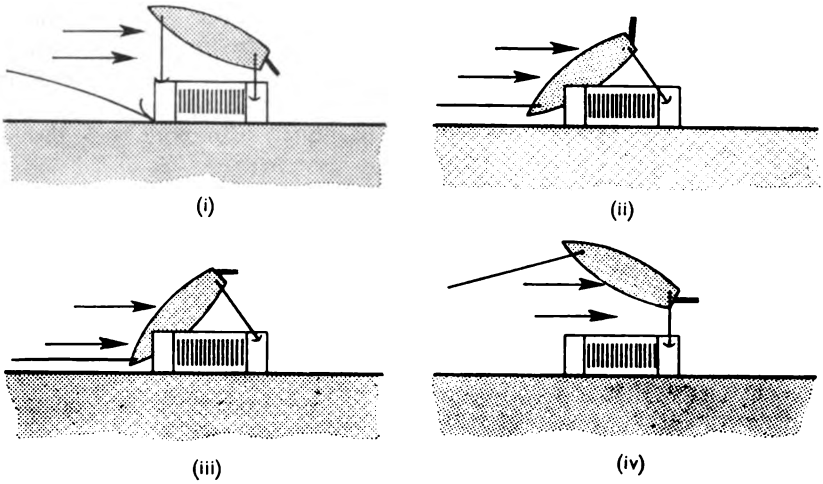


FIG. 8–1. Faults in handling a boat alongside

In fig. 8–1(i) the bowman has failed to secure the boatrope, the sternsheetsman has griped the stern to the ladder and the bows have swung out, the stream bearing on the inner bow.

REMEDY. Let go forward and aft, go ahead and come alongside again.

In fig. 8–1(ii) the boat has overshot the ladder, the bowman has griped in the bows and the stream on the outer bow has forced the boat under the ladder; the sternsheetsman cannot haul the stern into the ladder.

REMEDY. Let go aft, go full speed astern and come alongside again.

In fig. 8–1(iii) the bowman has secured the boatrope, but the boat is too far ahead and the coxswain has forgotten to use his rudder, thereby allowing the bows to swing into the ship's side. The sternsheetsman cannot haul the stern into the ladder.

REMEDY. Put on starboard rudder until the bows swing out, then steer the boat so that she remains parallel to the ship's side. If the bows will not swing out, the boat must be worked astern a few feet.

In fig. 8–1(iv) the bowman has secured the boatrope and the sternsheetsman has griped the stern to the ladder, but the coxswain has failed to use his rudder to keep the boat parallel to the ship's side.

REMEDY. Let go aft, put on port rudder until the boat is riding head to stream and clear of the ladder; then steer her gently in until she lies alongside.

Landing-place. When going alongside a landing-place take into account the direction and strength of the wind and tidal stream; whenever possible go alongside head to wind or stream, whichever has the most effect on your boat. A 1-knot stream is about equivalent to a wind of force 3 to 4, and a 2-knot stream to a wind of force 5 to 6. If the landing-place lies across wind or stream and there is a choice of sides, choose the lee side.

Always approach at slow speed and keep the boat heading in a safe direction in case her engines fail to go astern.

If manoeuvring space near the landing-place is limited, it may be an advantage to leave bows first, particularly in single-screw boats; the approach must then be made stern first, or the boat turned when alongside.

When going alongside a strange landing-place in suspected shallow water, approach slowly, taking soundings over the bows with a boat-hook.

Use of springs

In fig. 8–2(i) a headrope has been made fast and the boat can be brought alongside either by going slow astern or by allowing the wind or stream to do the work. In fig. 8–2(ii) a headspring has been made fast on the jetty and is secured abreast the pivoting point of the boat. By going slow ahead with the rudder to starboard, the stern will be brought into the jetty.

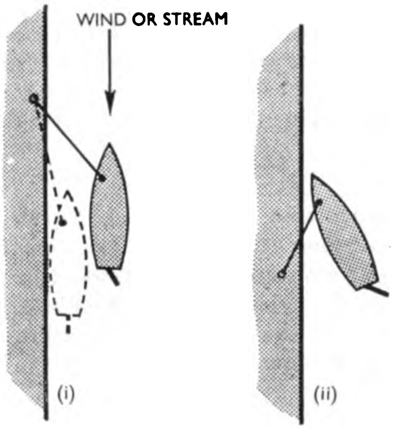


FIG. 8–2. Use of springs when going alongside

Once alongside, particularly when lying head to wind or stream, the head and stern ropes should be secured as springs (fig. 8–3(i)); they will be more effective in holding the boat alongside and are ready for springing off (described below).

Casting off

Lower boom. When leaving an inner billet at a lower boom in a tideway, drop astern to clear the outer boats; if you try to pass ahead of them, the stream may set your boat athwart their bows.

Landing-place. When leaving a landing-place always shove the boat well off before using the engines; if the boat is too heavy to shove off, cast her off on her springs with the help of the wind or stream, or by using the engines.

Springing off. When there is a head wind or stream, the bows can be sprung off by putting the rudder to starboard and letting go the headspring. When the bows have swung out far enough, go slow ahead with rudder amidships and let go the backspring (fig. 8–3(ii)).

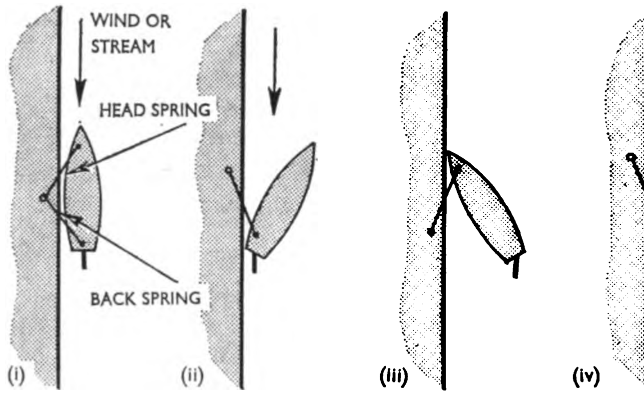


FIG. 8–3. Use of springs when casting off

When there is little or no wind, the stern can be sprung off by letting go the backspring, putting the rudder to port and going slow ahead (fig. 8–3(iii)); or the bows may be sprung off by holding on to the backspring and going slow astern until the bows have paid off far enough (fig. 8–3(iv)).

Shallow water

A boat running into shoal water at speed settles deeper in the water and trims by the stern; at the same time her hull wash increases, a stern wave builds up and the hull vibrates. If these signs become evident stop immediately and back astern into deep water on the opposite course. Avoid taking a boat into shallow, muddy, or sandy water, because the mud or sand will be churned up and may choke the cooling system of water-cooled engines.

Towing

When towing a pulling boat it is usual to use her painter as the towrope, bringing it to your lee quarter cleat with one turn round the stem of the cleat and half a turn round its after horn, the end being tended by the sternsheetsman so that the tow can be slipped at a moment's notice; on no account should a hitch be made or the end left untended. When towing more than one boat the heaviest should be first in the line of tow and the lightest last. Boats may be towed in calm water at fairly short stay, but in a lop or heavy sea the length of the tow should be increased until both boats ride comfortably. The total weight of the tow should not normally exceed the weight of the towing boat, otherwise an unfair strain will be put on her engines.

To tow a heavier vessel, such as a lighter, make her towrope fast as near to the pivoting point of your boat as possible; this may necessitate removing your after canopy. If the towrope is made fast to your quarter cleat the weight of the tow will gird the stern of your boat so that she will not answer her helm readily.

If the tow yaws badly pass another towrope from one quarter of your boat to the opposite bow of the tow (fig. 8–4(i)) and equalise the strain on both ropes. Another method is to tow the vessel on a bridle, one leg of which is

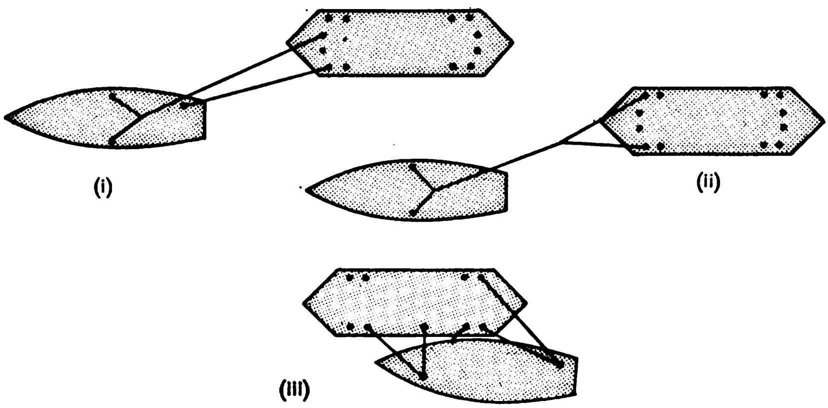


FIG. 8–4. Methods of towing

shorter than the other (fig. 8–4(ii)).

To tow a lighter alongside secure your boat to her quarter, as shown in fig. 8–4(iii). Your rudder and propeller are not blanketed by the lighter's wash, and your rudder exerts a far better turning moment about the combined pivoting point of the two craft than it would if your boat were made fast to the lighter amidships.

Engine order code

In boats not fitted with engine order telegraphs orders for the engines are given by blasts on a mouth-whistle or on a gong in accordance with the following code:

Order	*Meaning*
One blast or stroke	Stop. (In boats fitted with a Kitchen rudder the engine is stopped, but in other boats the engine is declutched and throttled down to idling speed.)
Two blasts or strokes	Normal full speed ahead.
Three blasts or strokes	Normal full speed astern.
Four blasts or strokes (two, pause, two)	Slow speed ahead. (In boats fitted with a Kitchen rudder the engine is throttled down to idling speed.)

ROUND-BILGE, SINGLE-SCREW BOATS

A revolving propeller exerts a sideways thrust on the after part of the hull, and the extent of this thrust and its effect on the boat depend upon:

(i) whether the boat is at rest or moving;
(ii) whether she is moving ahead or astern;
(iii) the speed at which she is moving; and
(iv) the rate at which the propeller is turning.

It is not necessary for the helmsman to understand the theory underlying the effects of a revolving propeller, but he should know what effects it has on the steering of his boat under various circumstances. The most important of these effects in a boat with a single, right-handed propeller are described here. The faster the propeller is revolving and the slower the boat is moving the greater will be these effects.

Boat at rest, propeller going ahead

If the rudder is amidships or to port the stern kicks to starboard, but if the rudder is to starboard the kick is counteracted (fig. 8–5(i)).

Boat gathering headway

As the boat gathers headway the side thrust of the propeller diminishes, and becomes imperceptible as soon as the boat gets steerage way.

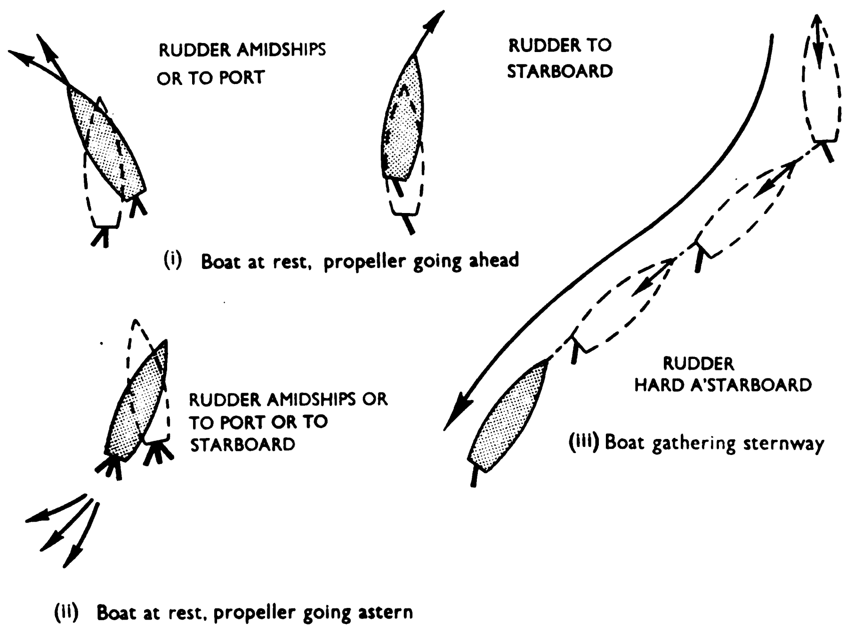


FIG. 8–5. Right-handed single-screw boat: from rest

Boat at rest, propeller going astern

The stern kicks to port whatever the position of the rudder, but the kick is more pronounced if the rudder is to port (fig. 8–5(ii)).

Boat gathering sternway

As the boat gathers sternway the stern continues to swing to port to a greater or lesser degree, according to the setting of the rudder (fig. 8–5(iii)); but as the speed of the boat increases so the turning effect of the rudder increases, and with starboard rudder the swing is reduced and, in some boats, may be checked completely. Very few right-handed, single-screw boats, however, can

be made to swing stern to starboard when going astern, even with the engine at full speed, but if the propeller is stopped when the boat has good sternway the rudder exerts its full effect.

Boat going ahead, propeller going astern

This is in some respects the most important reaction, because it occurs in emergency and when going alongside. As soon as the propeller starts to turn, the boat fails to obey her rudder in the normal manner and her subsequent behaviour depends on the position and size of her rudder. In the following examples (fig. 8–6) it is assumed that the engine is suddenly reversed to full speed astern when the boat is going full speed ahead, but the slower the boat is going ahead and the faster the propeller is turning the more marked will be her behaviour.

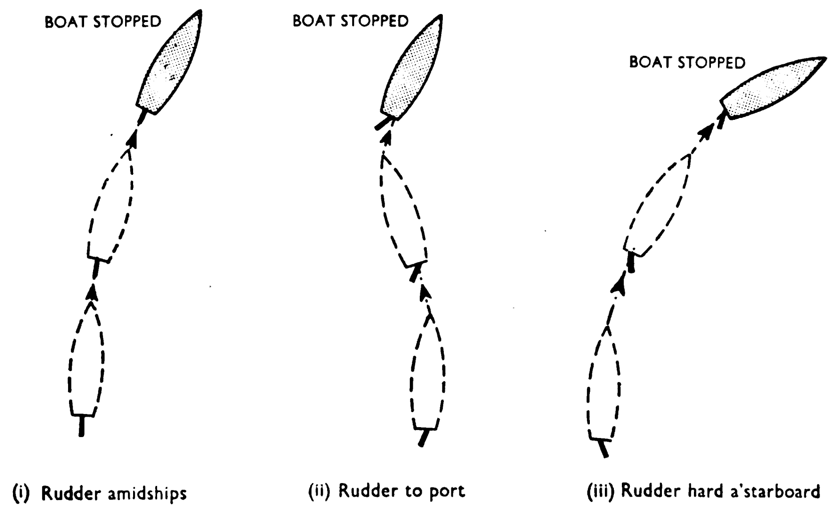


FIG. 8–6. Right-handed single-screw boat: engine full astern when boat is going full speed ahead

Rudder amidships (fig. 8–6(i)). The boat's head falls off to starboard and the boat gains ground to starboard before losing her way.

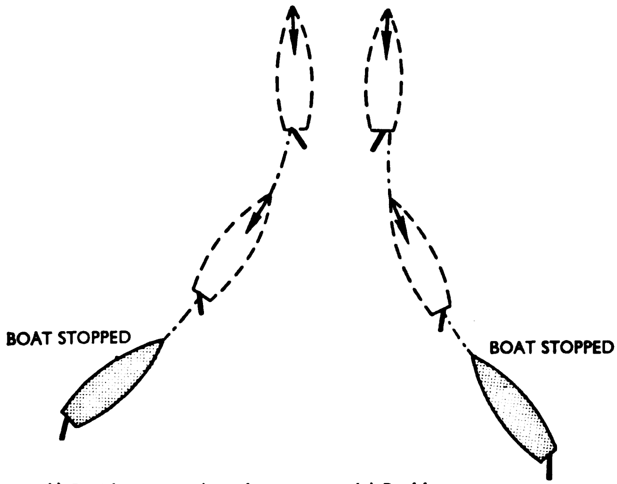
Rudder hard a'port (fig. 8–6(ii)). The boat's head usually goes to port first, but not far; it then begins to swing to starboard.

Rudder hard a'starboard (fig. 8–6(iii)). The boat's head pays off to starboard because both rudder and propeller tend to turn the boat that way.

Boat going astern, propeller going ahead

Here again the behaviour of the boat depends on the position and size of her rudder, her speed and the engine speed. If the engine is put to full speed ahead when the boat is going full speed astern, the boat reacts as follows (fig. 8–7):

Rudder amidships. No definite forecast of the boat's behaviour can be given, because so much depends on the type of boat.



(i) Rudder to starboard (ii) Rudder to port

FIG. 8–7. Right-handed single-screw boat: engine full ahead when boat is going full speed astern

Rudder to starboard (fig. 8–7(i)). The boat's head pays off to starboard—slowly at first, then more rapidly as the wash of the propeller impinges on the rudder.

Rudder to port (fig. 8–7(ii)). The boat's head pays off to port.

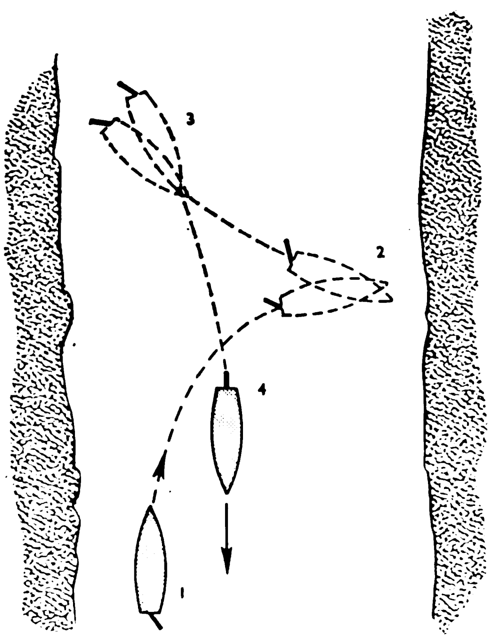


FIG. 8–8. Right-handed single-screw boat: turning in narrow waters

Turning a right-handed single-screw vessel in narrow waters

It will now be seen that the best way to turn a right-handed, single-screw vessel in narrow waters is to starboard, as follows (fig. 8–8):

1. Put the rudder to starboard and go ahead; the stern immediately kicks to port and will swing more rapidly as she gathers headway.
2. Reverse the engine and put the rudder hard a'port; the stern continues to swing to port.
3. Go ahead and put the rudder hard a'starboard; continue the movements of 2 and 3 as necessary until the vessel can achieve position 4.

If more convenient to go astern first, begin by going astern with the rudder hard a'port. If there is a strong breeze from the starboard side, avoid going astern too far or the vessel will tend to back into the wind. If the breeze is from the port side it will be advantageous to continue the sternboard until the stern is into the wind, if there is room to do so.

If there is sufficient room to go ahead and astern at fair speed for some distance it may be possible to turn to port, but the turn to starboard is always more easily and rapidly made.

Going alongside in a right-handed single-screw boat

When going alongside port side to, the boat can approach on a steady course at a small angle to the ladder, and when her engine is put astern to reduce her way the action of the propeller kicks her stern in towards the ladder so that she brings up squarely abreast it (fig. 8–9).

When going alongside starboard side to, the boat must make her final approach at a broad angle and with her head swinging to port, so that when her engine is reversed to reduce her way the swing of her stern to starboard counteracts the kick of her propeller to port and so allows her stern to swing gently in towards the ladder. This is a more difficult manoeuvre than the other and requires better judgment (fig. 8–9).

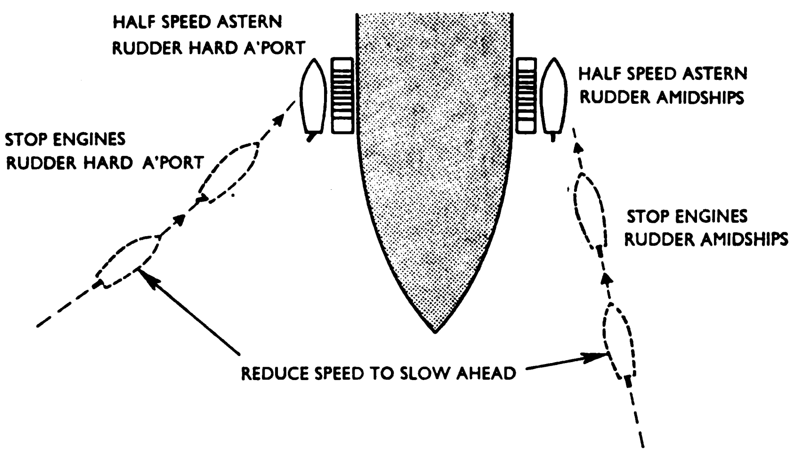


FIG. 8–9. Going alongside in a right-handed single-screw

ROUND-BILGE, TWIN-SCREW BOATS

Manoeuvring a twin-screw, round-bilge boat is much easier than manoeuvring a similar single-screw boat, provided that she has out-turning propellers. When both propellers are going ahead or astern at the same rate the sideways thrust of one cancels that of the other, and the boat answers her rudder in the normal manner provided that she has steerage way.

The boat can be turned at rest on her heel with her rudder a'midships by going ahead with one propeller and astern with the other, and by adjusting their rates of revolution so that the boat does not gather way either ahead or astern. But, if manoeuvring space allows, the boat can be turned more quickly if she is given a little headway or sternway with the rudder set in the direction of turn. Some boats turn better when going ahead and some when going astern. If there is a wind blowing some turn better if manoeuvred head to wind and some stern to wind. Each boat has its own peculiarities, so no hard and fast rules can be laid down, but when the boat is at rest, or moving slowly ahead or astern, she answers to the thrust of her propellers rather than the setting of her rudder.

ROUND-BILGE, SINGLE-SCREW 'KITCHEN' RUDDER BOATS

These are the most manoeuvrable of all single-screw boats, and are more manoeuvrable than many twin-screw boats.

The rudder consists of two curved metal plates mounted so that they encircle the propeller (fig. 8–10). The movement of the tiller to port or starboard turns both plates to starboard or port, respectively, in the same manner as an ordinary

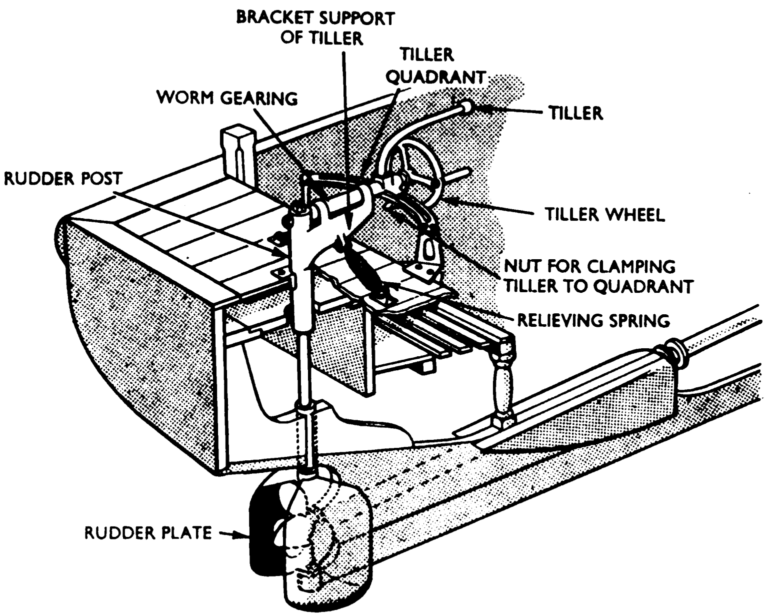


FIG. 8–10. The Kitchen rudder

rudder. In addition, the plates can be closed together abaft the propeller, or opened out on each side of it, by a shaft which revolves inside the rudder post and is controlled by a wheel and worm gearing on the tiller.

A *relieving spring* is fitted to each side of the tiller just before the rudder post to prevent the rudder from swinging from side to side and taking charge in a seaway. The fore end of the tiller is supported by a quadrant to which it can be clamped in any position along its arc of movement.

Rudder and propeller action

The propeller always moves in the ahead direction, and when the rudder plates are fully opened out its normal thrust propels the boat ahead (fig. 8–11).

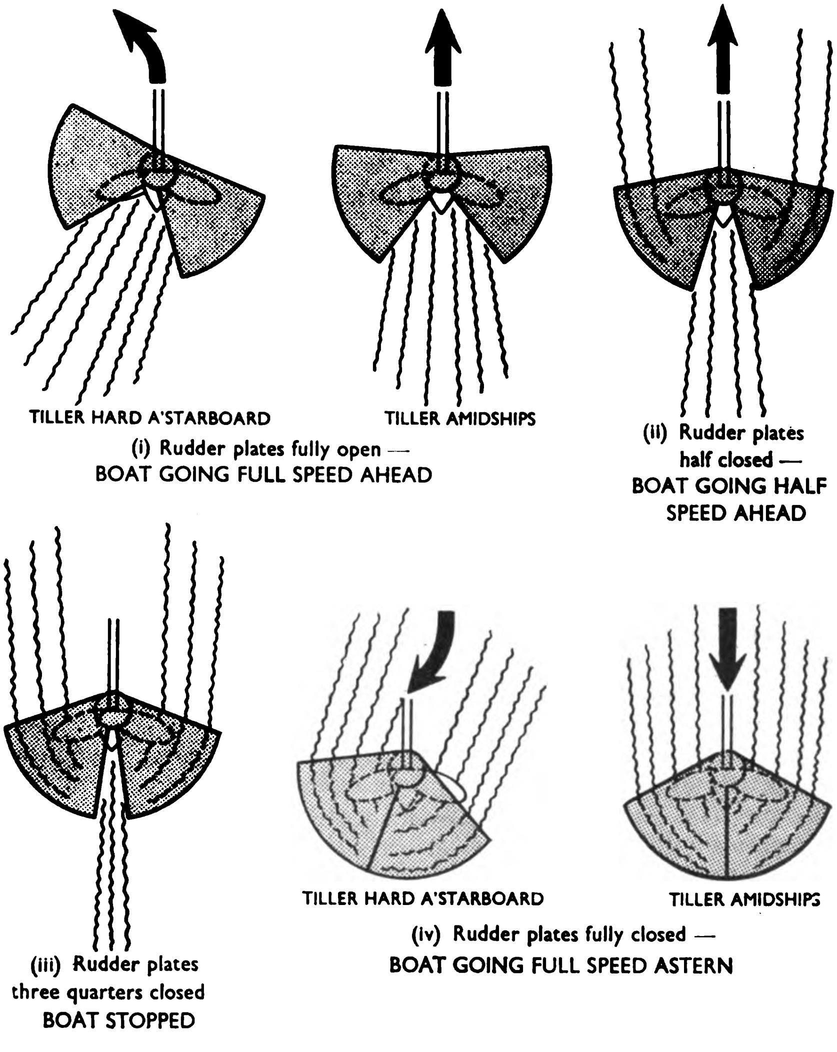


FIG. 8–11. The Kitchen rudder—rudder and propeller action

But if the plates are nearly closed abaft the propeller, its ahead thrust is neutralised by the backwash of its slipstream against the plates. If the plates are closed still further the backwash of the propeller slipstream against them overcomes the ahead thrust of the propeller and the boat is propelled astern. Thus by opening and closing the rudder plates the boat can be made to move ahead or astern at full, half, or slow speed, or be brought to a stop.

The Kitchen rudder, therefore, dispenses with the need for a reverse gear. Nevertheless, all Service boat engines are supplied with reverse gear which is normally 'locked out'. Ships may release the lock if they wish, and it is always released in survey boats, where there is a need to stop dead.

The boat is steered by the tiller as if she were fitted with an ordinary rudder, but when the tiller is moved the rudder effect of the plates is far greater and more effective at all speeds, and the boat will therefore answer her helm readily whether she is stopped, or going ahead or astern, however slowly or fast. When turning at rest the rudder exerts its greatest effect when the plates are fully closed, the tiller being worked as if the boat were going astern.

The speed of the boat, ahead or astern, can be controlled by the combined use of the tiller wheel and engine throttle, or by the tiller wheel alone with the engine running at constant speed ahead. When lying alongside, however, the engine is throttled down to idling speed.

HARD-CHINE BOATS

A hard-chine boat is designed to plane on the surface of the water at comparatively high speed, and therefore has a shallow draught, a flat bottom, and a greater beam than a round-bilge boat of similar length. The trim of the boat and her steering qualities are very different at high and low speeds.

At low speeds. From fig. 8–12 it can be seen that the hull has a 'V'-shaped cross-section forward and a rectangular cross-section aft. When at rest or moving slowly the draught is greater forward than aft, the pivoting point is at or near the bows and the boat tends to skid when under wheel. Because she is trimmed by the head the boat answers her rudder sluggishly and, when the propellers are at rest, the rudder has little or no effect.

At higher speeds. When the boat is moving at speed in her planing trim the forefoot is out of the water and the stern and rudder are well immersed; the pivoting point moves aft, and she steers well. Under normal conditions the boat should be run at a speed which will allow her to attain her planing trim, but if she is overloaded she will be unable to attain it and will plough sluggishly through the water, shipping water and straining the engine and hull.

Top-weight. Because of their shallow draught and high freeboard these boats are particularly susceptible to top-weight; therefore they should never be overloaded, and passengers and stores must be stowed within the hull, never on the deck or canopies.

In heavy sea. The behaviour of a hard-chine boat in a seaway depends upon the length and steepness of the seas in relation to the length and speed of the boat. In favourable conditions she will plane at high speed with comparative ease over seas which would be uncomfortable for a round-bilge boat; but in unfavourable conditions she will pound so badly that her speed will have to be

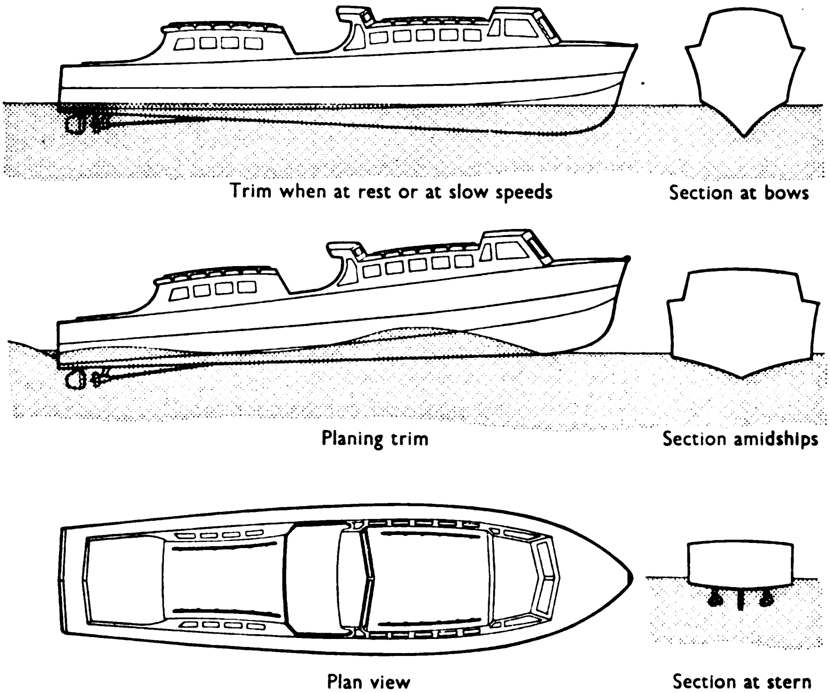


FIG. 8–12. A hard-chine boat

reduced below her planing speed, and then she will wallow sluggishly and require very careful handling, particularly in a quartering sea.

Single-screw

Most of these boats have right-handed propellers, and remarks on their handling apply to those so fitted.

When manoeuvring, avoid declutching the propeller and allowing it to idle, because the rudder must have a flow of water past it to be effective. If, for example, the clutch is put into neutral when the boat is going slow ahead and swinging to port, putting the rudder hard a'starboard has no result and the boat continues to swing to port.

If the boat is going ahead and the propeller is put astern, the stern kicks markedly to port; and when the boat and propeller are both going astern the rudder has little effect unless the boat has considerable sternway. The marked kick of the stern to port can be used to advantage to turn the boat at rest; by giving her short bursts ahead and astern she can be turned to starboard almost in her own length, provided that the rudder is hard a'starboard before each burst ahead, because this is when the most pronounced turning effect is produced.

When going alongside, the boat should be kept on a steady approach course at an angle of 20° to 35° with the ship. If too much wheel is used after speed is reduced the boat yaws and is difficult to steady; steering at slow speed can only be achieved with practice. If the boat is to be placed port side to, go astern

with the wheel amidships and the kick of the propeller brings the stern in. If the boat is to be placed starboard side to, put on plenty of port wheel just before going astern; this has the initial effect of swinging the stern in quickly, but the kick produced by the propeller on going astern checks the swing. The interval between putting the wheel over and going astern should be only a second or two, depending on the original angle of approach, and this, again, can only be judged with practice.

Twin-screw

In many of these boats both propellers rotate in the same direction, i.e. both left-handed or both right-handed. When the propellers are out-turning, handling is similar to that of twin-screw round-bilge boats, but because of their shallow draught the kick of the propellers is more marked. If both propellers are right-handed, the boat usually turns better at rest to starboard than to port. If both propellers are left-handed the boat usually turns better to port.

When going alongside the angle of approach depends on the direction of rotation of the propellers. If they are out-turning the approach can be made at a fine angle and the boat stopped alongside by using the outer propeller only. If the propellers are both right-handed or both left-handed the approach should be made as for a single-screw boat for the same direction of rotation.

Triple-screw

A few boats are provided with three propellers, and when manoeuvring it is best to stop the centre propeller and manoeuvre the boat as though she were a twin-screw boat; the extra power of the centre propeller will be useful, however, if it is desired to reduce speed rapidly.

MONOHEDRAL BOATS

These boats are of V section, with a steep angle of deadrise which is constant throughout the length of the boat. They are a compromise between round-bilge and hard-chine, having a high speed and good sea-keeping qualities.

HANDLING BOATS' ENGINES

A boat's engine is called upon to perform a very arduous duty. The engine is usually running nearly at its full power while the boat is under way, it is frequently required to develop high power from cold with little or no warming up, and its hot running time is interspersed with periods when the engine is idling alongside ships' gangways. All these conditions tend to increase the rate of wear of the engine, which is expected to run for a certain number of hours between overhauls, usually between 1,000 and 4,000, according to its type.

The engines of Service boats are designed to fulfil these conditions, but they will only do so when handled with reasonable consideration and maintained strictly in accordance with the schedule laid down.

When a seaman rating takes over duty as coxswain of a boat he should,

whenever possible, be given practical instruction by the Engine Room Department on the best method of handling the engines and their reversing gear.

Starting

It should be a matter of daily routine to check the amount of lubricating oil in the sump before first starting the engine, and also to make sure that the circulating water system is vented and flooded. The flow of circulating water and the lubricating oil pressure should always be checked before getting under way.

A warm engine should start without trouble; failure to do so indicates that something is wrong, and technical assistance should be sought. A very cold engine is more difficult to start for several reasons, the most usual being the thickening of the lubricating oil owing to its low temperature, which reduces the speed at which the starter can turn the engine. Use of the correct grade of oil and regularly draining and refilling the sump in accordance with the maintenance schedule prevent this effect from becoming excessive.

The starting routine and control settings should be based on the instructions given in the engine-maker's handbook, and then be modified as necessary by actual trial and experience, as these will be found to vary even between engines of the same type. The routine finally selected should invariably be adhered to. A cold engine should be warmed up fairly rapidly by running it at about half the full engine revolutions. Full speed should not be attempted until the engine is thoroughly warmed up.

It is most important to find the most suitable method of operating any starting aids such as 'Kigas'. All starting aids must be used only as such; once the engine is running they do no good and may cause rapid wear.

Stopping

If the maker's handbook advises any particular routine for stopping the engine it should be followed, because it is designed to leave the engine in the best condition for easy restarting.

It is important that all valves, cocks and controls should be left in the correct positions when the crew leaves the boat. Accidents are frequently the result of leaving a cock or valve open which should normally have been left shut, and vice versa; it is very easy to overlook these things when a boat is called away in emergency and the engine may not start, or it may break down. When the engine or its gears have to be left in an unusual condition, a note calling attention to the fact should be attached to the starting controls.

Running

The speed of the engine must always be kept well under control when manoeuvring, because an engine 'running away' in neutral gear is subjected to stresses appreciably higher than those experienced when running steadily at full power.

The maximum power and revolutions per minute of most diesel-type boat engines are controlled by governors. Adjustments to the governors (or fuel lever stops, where fitted) must not be made without the authority of an engineer officer. The diesel engine will always develop extra power if given extra fuel, but this extra power is obtained at the risk of serious breakdown. If correctly

adjusted, the governor will prevent overloading under normal conditions, but it will not necessarily do so when towing or when under other abnormal conditions, and coxswains of boats must ensure that under such conditions the boat's speed is reduced as necessary to avoid overloading. Any darkening of the colour of the exhaust gases, or labouring or overheating of the engine, are signs of overloading. Inability to reach the normal r.p.m. with the relative fuel setting also indicates that the engine is overloaded. The cause of a dirty exhaust should always be investigated without delay. Petrol engines are less liable to overloading, because the fall in r.p.m. reduces the quantity of petrol supplied by the carburettor, but caution is necessary when towing.

A boat should not be run when its clutch is slipping. A few minutes' running under these conditions may necessitate a major repair instead of a minor adjustment.

Sandy and muddy water

Running a water-cooled boat in sandy or muddy water is liable to result in choking the circulating water system. The engine should be watched carefully for overheating, and if this occurs the engine speed should be reduced and the circulating system be cleaned out, or flushed out with clean water, at the first opportunity.

Signs of defects

Some defects, such as misfiring and loss of power, are obvious. Others are less obvious but usually give some indication of their existence—for example, overheating; smell (this points to the necessity for keeping an engine clean: a dirty engine will smell all the time, thereby hiding this indication of trouble); noise; vibration; and leakage (one example of which is an unexplained increase or decrease of oil: an increase in the oil level may be caused by water leakage into the sump). Boats' crews need not be trained to deduce the nature of a defect, but it is essential that they should be trained to be alert for indications of defects.

Handling a defective engine

If running a boat with an untraced defect in the engine is unavoidable, it is usually safe to assume that the lower the speed of the boat and the power being generated by the engine the less is the danger of serious damage or complete breakdown; but this rule must be modified if serious vibration occurs, in which case the lowest speed which is reasonably free from vibration should be chosen.

Propellers and shafts

Propellers are vulnerable in almost all types of boats, but propellers, shafts and brackets of hard-chine boats are extremely susceptible to damage. Carelessly handling boats when alongside jetties, or running them in shallow water, will often incur a great deal of otherwise unnecessary maintenance work. Any abnormal vibration which may develop in the propeller system should be investigated without delay.

MAINTENANCE OF ENGINES

Each type of engine is assessed, according to its rating, power-to-weight ratio, and past experience of its wearing characteristics, to be capable of a certain number of hours' running under normal conditions between major overhauls. This overhaul period is based upon the assumption that the engine is properly maintained while in service.

Maintenance schedules

Maintenance schedules lay down the maintenance routines to be carried out between major overhauls. The technical departments must be given the opportunity to carry out these routines, because failure to do so will eventually affect the engine's reliability. These routines are based on normal conditions: additional and more frequent maintenance may be required if the engine has been subjected to abnormal usage.

Major overhauls

The periodical major overhaul of the engine is a process of reconditioning designed to make the engine fit to run reliably for a further period of equal duration. To run the engine appreciably beyond the time when it is due for overhaul is to invite serious trouble, and may also seriously increase the cost and time of overhaul when this is undertaken.

Major overhauls require specialised equipment, and must therefore be carried out in the dockyard whenever possible.

If the ship is at a place where there is considerable delay in obtaining replacement engines from the spare engine pool, it is advisable to work the boats so that the dates on which their engines become due for overhaul will be staggered.

Minor defects

Even with good maintenance, minor defects may develop and lead to serious breakdown if neglected. The boat's crew is not normally competent to judge whether a minor defect is likely to cause major trouble, so all defects should be reported without delay to the technical department.

Water danger

The petrol engine is very sensitive to water, particularly salt water, because of its electric ignition system. The diesel engine is far less sensitive to water because of its compression ignition system, but water will impair the functioning of its electric starting system. Furthermore, the metals of which both types of engine are made are easily corroded by salt water. It is therefore bad practice to run a boat with leaky engine-room hatches, or to drive the boat in such a way that water is shipped down the engine-room ventilators.

Fire danger

With petrol there is always danger from fire. Being heavier than air, petrol vapour collects near the bilges, and the absence of any smell of petrol when standing up in the engine compartment is no guarantee of freedom from this

vapour. Where fitted, exhaust fans must be run for a minimum of 10 minutes before starting.

The necessary precautions to guard against fire are laid down in various regulations and orders, but the following points are often overlooked:

1. Petrol vapour will seep from one compartment to another by most unexpected channels.
2. When starting up there is always a danger of fire from the engine back-firing, from short circuits due to damp on electric leads, and from the engine compartment having probably been without any form of ventilation for some time.
3. An insignificant petrol leak can lead to the destruction of the entire craft, and the less accessible the petrol joint the more important it is to inspect it frequently.
4. The gas oil or diesel fuel used for compression ignition engines does not usually give off inflammable vapour, but this must not be allowed to lead to a complete lack of precautions; although a diesel fuel fire is more difficult to start, it is just as dangerous as—and sometimes more difficult to control than—a petrol fire.

Bilges

Water in the bilges is undesirable from every point of view. Apart from its endangering the boat's stability when present in considerable quantity, it usually contains salt, which is dangerous and corrosive to electrical systems; and highly inflammable liquids, such as petrol, float on it and so increase the risk of fire. Bilges must therefore be kept dry, and bilge-clearing arrangements should be tested frequently and maintained as thoroughly as the main machinery. Cleanliness of bilges is essential, because the bilge-clearing arrangements can easily be choked—by dirt and rags, for example.

Cleanliness

Boat machinery requires real cleanliness, not polish, though polish is desirable as a finishing touch. Dirty machinery can be a danger to the safety of the boat.

Lubrication and maintenance by boat's crew

All greasing and other hand lubrication must be carried out to a definite routine; to do this when convenient is not good enough. The Boat Officer and others in charge of boats should arrange routine times for greasing and general maintenance duties.

The routine maintenance items for each type of boat engine are laid down in its 'Maintenance Schedule'. These schedules cover only the engine and its ancillary gear; all other working parts, such as controls, steering gear, winches and anchor gear, and hatch and door hinges and clips, should be attended to regularly according to a routine made out for each boat.

Technical departments

The responsibility of the various technical departments for the boat's equipment is clearly laid down, and this division of responsibility should be

strictly maintained. Much can be done to assist the technical departments by early reports of defects, by allowing them adequate time for maintenance, and by arranging trial trips for the boat when required.

On the other hand, the technical departments can assist the Seaman branch by arranging for competent artificers to take periodical trips in the boats to ensure that the machinery is in a satisfactory mechanical state. The small trouble and inconvenience of these arrangements will be more than repaid by the resulting increase in the boat's reliability.

HANDLING BOATS IN FOUL WEATHER

Riding to a sea anchor

If a boat is overtaken by a gale when she has plenty of room to leeward it is usually safer to let her drift with the wind and sea, provided, of course, that she is not blown out to sea or too far from her destination. In a sailing boat all sails must be lowered and the masts as well, if possible. If she has little sea-room, however, it is best to ride out the gale to a sea anchor, which is also used as the boat's drogue; it consists of a cone-shaped bag of canvas open at both ends, the larger end being secured to the boat's cable. The drogue is streamed over the bows and paid out to a clench; the boat then rides head to wind as she drags the drogue slowly through the water. The drogue should have the following dimensions:

diameter of the mouth: one inch for every foot length of boat at her waterline

length: one and half times the diameter of the mouth,

diameter of the tail: about one-eighth of the diameter of the mouth.

The drogue is fitted with a four-legged bridle and the mouth is held open by an iron hoop, which should be heavy enough to sink the drogue below the surface. When no longer required, the drogue is tripped and hauled in tail-first.

If a proper drogue is not available, an extempore one can be rigged from a foresail with a three-legged bridle bent to its corners; a hole about 4 inches in diameter must be cut in the centre of the sail, and one corner must be weighted so that it tows upright. If no sails or awnings are carried, a sea anchor can be made by securely lashing together oars, stretchers, gratings and other such fittings, and then securing them by a two-legged bridle to the boat's cable so that she will drag them broadside on through the water.

Depending on the characteristics of the boat, it may be better to stream a warp over the stern than to use a sea anchor over the bow.

The waves can be prevented from breaking heavily by oil dripped over the bows in small quantities from a large can or drum; any oil will do, but animal or vegetable oils are the most effective. The amount required is not great: oil dripped at a rate of between one and two pints an hour should be sufficient appreciably to calm the sea to windward.

Hoisting a swamped boat

Before hoisting a swamped boat it should first be made fast under the davits or crane by a headrope and sternfast. The falls or purchase sling should then

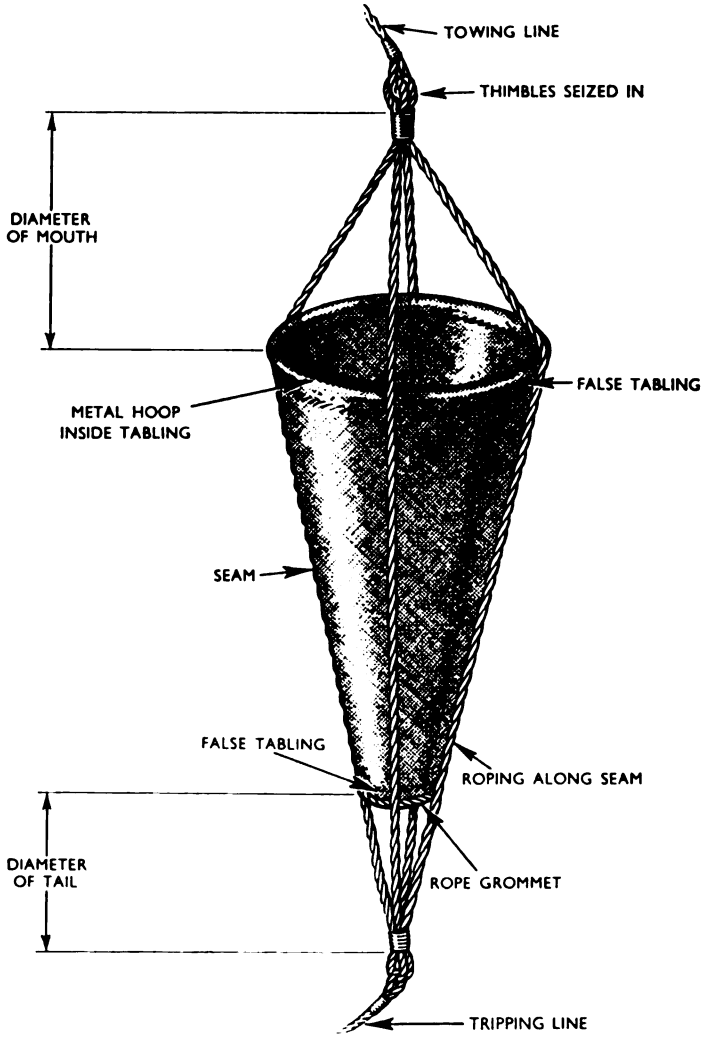


FIG. 8–13. A sea anchor or drogue

be hooked on to the boat's slings, and all slack taken down; if the boat is not fitted with slings, extempore slings must be passed under her bows and quarters and be kept from crushing the gunwale by athwartship spreaders. The boat should then be bailed out while the falls are kept taut: no attempt should be made to hoist her until most of the water is bailed out, but when nearly empty she may be hoisted a few inches by the foremost fall to spill the water over her stern and so assist the bailers. When almost empty of water, the boat may be hoisted clear of the water and allowed to drain, and then be hoisted in the usual manner.

Hoisting boom boats

Hoisting out. In rough weather special precautions are necessary if there is any appreciable movement on the ship. The ship's side and the boat should be well fendered. Long 2½-inch jiggers should be used for the steadying lines, and they should be secured to the boat's bow and quarter cleats with wire rope strops. Two headropes should be rove, one as a boatrope through a clump block on the lower boom, and the other from well forward in the ship outboard of all and secured in the bows of the boat; and two sternfasts should be led from well aft and secured in the stern-sheets. The headropes and sternfasts should be tended to prevent the boat surging as she is lowered. If the ship is rolling heavily it may be found advantageous to work the topping lift of the derrick or crane so as to lower the boat against the ship's side. When the boat is in the water she is hauled clear of the side to the lower boom on the boatrope. The crew must not be in the boat when she is slung inboard.

Hoisting in. In rough weather a boat's crew may have difficulty in hooking the sling to the purchase hook of the crane or derrick; this is made easier if a tricing line is rove at the head of the crane or derrick, as shown in fig. 8–14; the end of the line is passed into the boat, rove down through the ring of the sling, and hooked to the link on the bill of the purchase hook, so that the ring of the sling is triced on to the purchase hook as the hook is lowered.

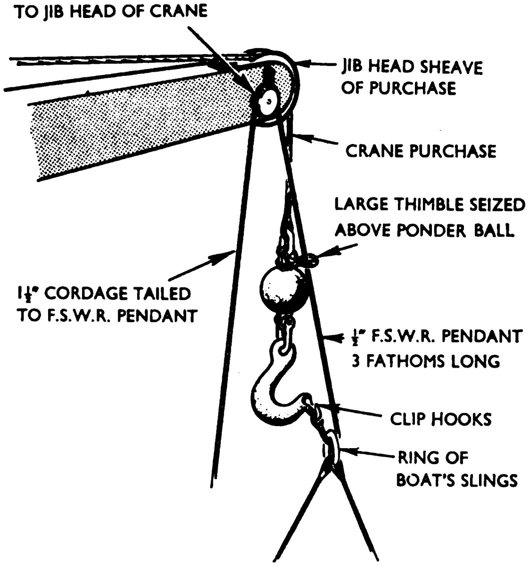


FIG. 8–14. Tricing line rove for hooking boat's sling to hook of crane purchase

In particularly rough weather the ship's side should be well fendered, oil should be poured on the water forward to prevent the seas from breaking, and the boat should be dropped astern on her boatrope from the lower boom to the derrick or crane. Another headrope should be led from well forward in the ship

and secured in the bows of the boat, and an extra sternfast should be passed. As the boat is hoisted clear of the water the headropes and sternfasts are tended and the boatrope cast off; and when she is level with the deck the steadying lines are made fast, *the crew leave the boat*, and she is hoisted inboard.

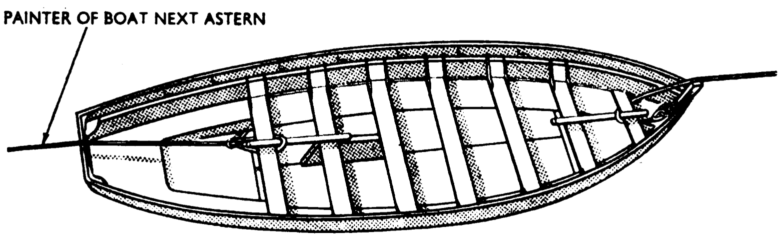
SPECIAL BOAT OPERATIONS

Towing pulling boats

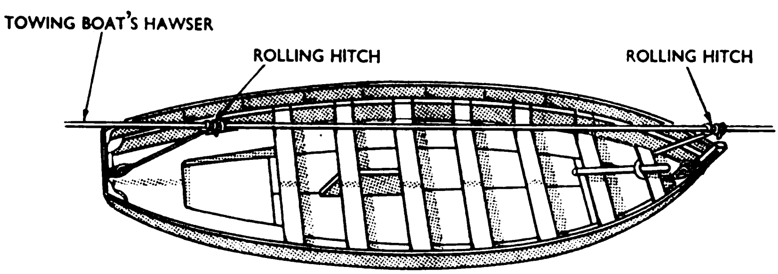
A lightly laden boat may be towed for a short distance in calm weather by her painter, which should be made fast with two or three turns round her towing bollard. If no bollard is provided a wooden bar should be passed through the bight of the painter and laid over the two foremost thwarts (fig. 8–15(i)). A boat should never be towed direct from her stem ringbolt, because this puts an unfair strain on the ringbolt and stem. The painter should be brought to the quarter bollard of the towing boat and tended by the sternsheetsman, who should be ready to cast if off at a moment's notice. One hand should be stationed in the bows of the towed boat ready to cut the tow in emergency, and the boat should be trimmed by the stern.

Some boats can be towed from their *riffles*, which are holes drilled at the ends of the keel, lined with a metal bush and designed to take a long shackle.

The length of the tow should be adjusted so that the forefoot of the boat rides on the crest of a wave in the wake of the towing boat. When a boat laden with men is to be towed a special towing painter is usually provided, the end of



(i) Towing a boat not fitted with a towing bollard



(ii) Towing a string of boats

FIG. 8–15. Methods of towing pulling boats

which is brought to the towing bollard with four round turns and backed up by the bowman. When being towed in a heavy following sea a drogue should be streamed to prevent the boat from being carried along on the crest of a wave and possibly broaching to.

If a second boat is towed astern of the first a bowline should be made in the end of her painter and secured in the stern-sheets of the first boat by a wooden bar passed through the bight of the bowline and laid across the two after thwarts (fig. 8–15(i)).

When several boats are towed astern of each other they should be towed in the order of their size, with the largest boat leading, and each should be secured to the boat ahead of her as described above. If they are to be towed for a considerable distance, the towing boat may provide a hawser to which each boat should be secured by her bow and stern painters with a rolling hitch (fig. 8–15(ii)); the hawser should be served to prevent it from being chafed at the bows and stern of each boat.

Beaching a boat

A small boat can be beached by the crew lifting and launching her shoreward. For beaching a heavier boat, make a strop with the boat's cable, pass it round the boat just above the keel, and hang it in place by lanyards secured to the risings; or secure a long shackle in the riffle. Take three short spars to serve as rollers; place the first one under the forefoot of the boat and the other two up the beach, so that all three are spread about one-third of the boat's length apart. Then man the cable, or a purchase hooked on to it or the riffle shackle, and haul the boat up the beach, taking care to keep her on an even keel and to keep her bilges clear of rocks or large stones. As the boat should be hauled above the high-water mark it is easiest to beach her at high water. A boat should never be left unattended if beached below high-water mark, because she will probably be damaged by bumping and broaching to when the rising tide reaches her.

HANDLING BOATS IN SURF

Surf

The movement of water in a wave as it passes over the surface of the open sea is circular, backward from the trough to the base and then upward and forward to the crest. When the wave reaches shallow water its forward speed is reduced, and the momentum of its forward movement expends itself in increasing both its height and the violence of the forward and backward movements of the water within it. The wave thus grows steeper and rises to a sharp crest, until finally it breaks, falls forward and downward and throws forward a mass of frothy, unbuoyant water from the line where it broke. Breaking waves caused by tide-rips or by isolated submerged rocks, reefs and other underwater obstructions are called *breakers;* and one or more lines of breakers occurring along a shore or over an extensive shoal are known as *surf.*

Surf may be caused by the swell from a storm hundreds of miles away, by the sea raised by a local onshore gale, or by a combination of both. Waves caused by either a swell or a sea will arrive at fairly regular intervals, but the

intervals between those from a swell will be much longer; a combination of swell and sea will produce confused conditions, particularly if they come from different directions, and any resultant surf will be confused and unpredictable. It is therefore easier to negotiate surf from a swell than surf from a sea; and the most difficult to negotiate is that from a combination of the two.

The *extent* of surf seaward from a coastline depends chiefly on the bottom gradient. Over a shallow gradient a heavy swell may produce surf extending for as much as a mile seaward, whereas the same swell on a steep gradient may only produce one line of breakers. In tidal waters the extent of surf may vary with the state of the tide, particularly when the tidal range is large and the gradient is shallow below the low water mark and steeper above it; at such places the surf will be more extensive at low water than at high water.

The *intensity* of inshore surf depends chiefly upon the height of the waves, the speed of their advance, and the gradient of the bottom; high and rapidly advancing waves which pass abruptly from deep to shallow water will produce a dangerous belt of surf, whereas the surf produced by the same waves if advancing over a shallow gradient will be much less. In tidal waters the intensity of a surf may vary with the state of the tide, particularly when the tidal range is large and the gradient is shallow below the low water mark and steeper above it; at such places the surf will be more intense at high water than at low water. The extent and intensity of surf which may occur on a beach can therefore be roughly gauged from the gradient of the bottom; and in tidal waters it can be gauged from the gradients of the bottom and the beach, and from the range of the tide.

The position at which any particular wave may be expected to break depends upon its height and speed of advance and upon the depth of water. Though the speed of advance of all waves in any particular sea or swell is about the same,

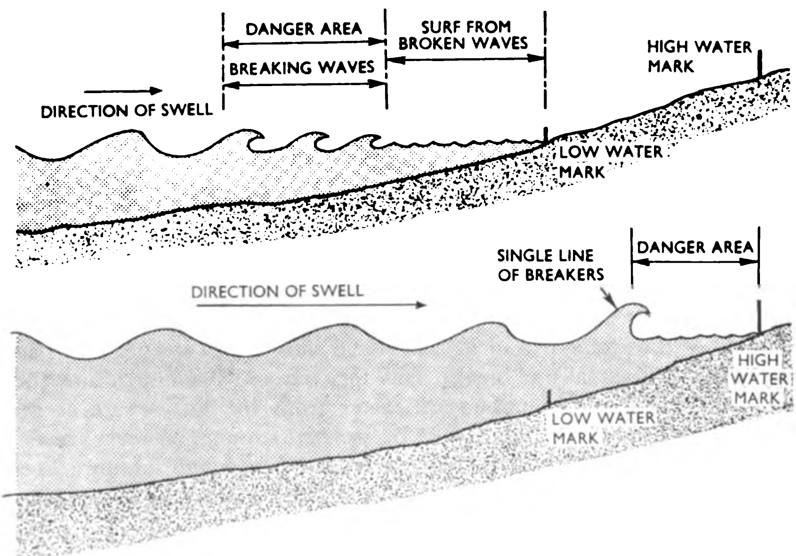


FIG. 8–16. Danger area of surf

there is usually a considerable difference in their height, and the larger waves will break further offshore than the small waves; also, in tidal waters all the waves will break closer inshore at high water than at low water (fig. 8–16). It is the breaking wave which presents the greatest danger to boats negotiating a surf; the *danger area* of a surf, therefore, extends from the seaward line of these largest breakers to the inshore line of the smallest breakers, and to negotiate it safely in a boat requires an experienced coxswain and a well-trained crew.

Crossing this danger area would always be hazardous but for the fact that the waves usually advance over it in recurring cycles, of being first high and then gradually lower, with sufficient regularity to enable the coxswain of a boat to predict a comparatively calm period in which to cross; but the popular belief that the seventh, fifth or any other particular wave is the highest is quite fallacious.

The extent and intensity of surf to be expected also depend upon the direction from which the sea or swell advances in relation to the direction in which the shore lies, and upon the shape of the beach. Where the sea or swell runs parallel with the shore far less surf can be expected than where the waves are rolling directly into a bay. A sea or swell running into a wide bay will cause a fairly regular surf over the whole, but waves running into a deeply indented bay tend to rebound from one side to the other, creating a cross-swell and confused surf.

Undertow. A peculiarity of surf, particularly in shallow water, is the undertow in front of a wave which is about to break. This is caused by the water in front of the wave being drawn rapidly into the base of the front of the wave as it curls upwards and forward and then breaks. If caught unawares, a man wading in shallow surf may be overthrown, dragged by the undertow into an oncoming wave, then drawn further seaward into the next wave, and so on until he is drowned; when working on a beach in heavy surf men should therefore wear lifelines.

Selection of a boat for landing in a surf

A boat to be used for landing in a surf should possess the following qualities:

have sufficient freeboard to prevent her being swamped in the frothy unbuoyant water of surf;

be sufficiently buoyant at each end to allow her to ride over the waves and not through them, and to allow one end to rise to a wave without submerging the other. (She should not, however, be too lively; otherwise the crew will not be able to work the boat.)

have good powers of acceleration ahead or astern;

have good manoeuvrability, both ahead and astern, in all conditions and particularly when stopped or moving at the same speed as the water;

be light enough to be manhandled by her crew when beaching or launching.

A transomed boat is more liable to surf-ride, i.e. be carried shoreward on the forward slope of a wave or by fast-moving surf, than a double-ended boat. She is also more difficult to steer in a following sea and when going astern.

A pulling boat is preferable to a small power boat, because:

1. When pitching, the propeller of a power boat may often be out of the water and so useless.
2. A power boat has poor manoeuvring ability when going astern.
3. A power boat has comparatively poor acceleration, particularly when going astern.
4. A propeller does not grip the surf as effectively as oars.

The boat should be fitted with buoyancy blocks in the bows and stern to provide additional buoyancy at each end and to prevent any water in the boat from collecting there. Anything of weight in the boat should be stowed amidships.

A double-banked pulling boat is preferable to a single-banked boat, and if possible she should be equipped with a set of short oars, and the crutches should be secured to their sockets. Short oars are more easily handled in surf than long ones and are less likely to be unshipped by the surf from long-jawed crutches, and double-banking the boat gives increased power with maximum manoeuvrability and allows the crew to be evenly distributed amidships.

Steering. A boat's rudder is useless in surf, because it has no effect when the boat is stopped or moving at the same speed as the water, and when pitching heavily it is useless through being frequently out of the water. Whatever type of boat is used, she should therefore be steered by an oar shipped right aft in a closed crutch or a grommet, and if practicable her rudder should be unshipped.

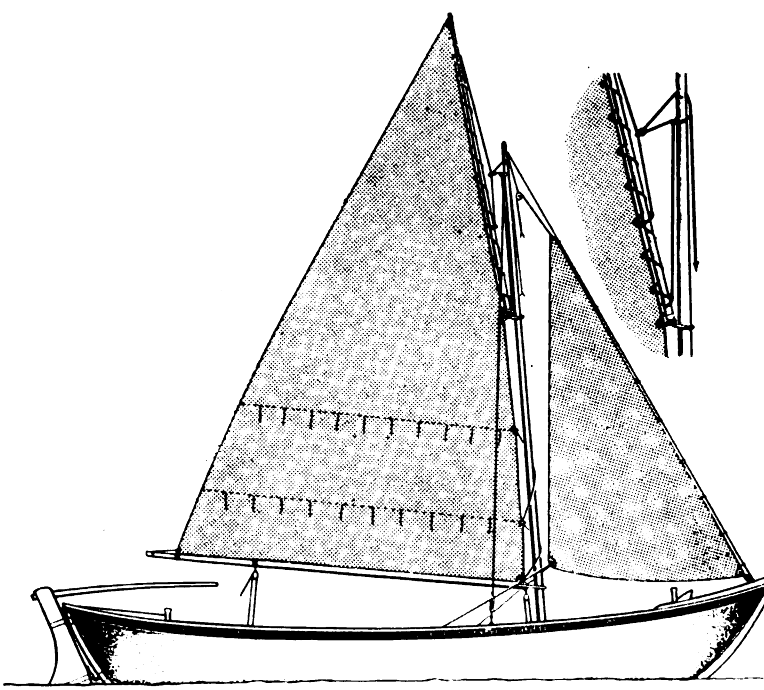


FIG. 8–17. Sailing rig of a 27-ft surf boat

Description and rig of 27-ft surf boat

This is a double-diagonal-built pulling and sailing boat (fig. 8–17), of similar dimensions and weight to the 27-ft whaler, but specially designed for landing in a surf. The gear and fittings differ from those of the 27-ft whaler in the following respects:

Two sets of oars are provided, a single-bank set of 5 for normal purposes and a double-bank set of 10 shorter oars for pulling through surf, together with a long steering oar. The crutches are of special shape to prevent the oars jumping out of them in a rough sea, and they can be stowed without removing them from their sockets.

The boat is gunter-rigged, i.e. she has a foresail and an almost triangular gaff mainsail with the gaff topped close to the mast, and the foot of the mainsail is bent to a boom.

A rotary bilge pump is provided, in addition to hand bailers; a watertight locker is provided each side amidships, for the stowage of surveying instruments; the stretchers are of half-round section, so that they may be placed below the keel when hauling the boat up a beach; a riffle is drilled at each end of the keel to take a long shackle for the hook of a purchase for hauling the boat up a beach; a bollard is provided on each quarter for working the drogue warp when running before a heavy sea or through surf, and lumber irons are provided for stowage of spars.

In addition to the normal foresail and mainsail, a Genoa jib, a storm trysail and a storm foresail are provided. In a rising wind sail may be shortened progressively by first hoisting the storm foresail instead of the foresail, then taking down reefs in the mainsail and, lastly, by hoisting the storm trysail in place of the mainsail.

The mast is stayed by a forestay and two shrouds of wire rope and is stepped through a clamp on the mast thwart and a hole in the floorboards into the keelson. The upper ends of the forestay and shrouds are fitted with soft eyes which are placed over the head of the mast, and their lower ends are fitted with rigging slips; the shrouds are also fitted with bottlescrews, by which they are set up. The rigging slips are locked with split pins, which should always be inserted when the sailing gear is rigged.

The fore halyard is a single whip rove through a block on a pendant at the masthead. The eyes of the fore halyard pendant, forestay and shrouds are placed over the head of the mast in that order.

The gaff of the mainsail is fitted with a wire span, on which is shackled a bullseye. The main halyard is a double whip with its standing end secured to the throat of the gaff; it is rove through a bullseye on a strop at the masthead, down through the running bullseye on the span of the gaff, back round the sheave at the masthead, and down to its belaying pin in the mast thwart. When the storm trysail is used the running bullseye is shackled to its head, and the standing part of the main halyard is made fast to the mast thwart.

To the heel of the boom is shackled a tack tackle, the standing block of which is shackled to a ring in the floorboards just abaft the mast. When bowsed down it is belayed by hitching the hauling part round the running parts.

The head of the mainsail is laced to the gaff with a spiral lacing, and its luff

is laced to the mast, as shown in fig. 8–17. The tack is hooked to the heel of the boom, and the clew to the hook of an outhaul fitted to the end of the boom; in light winds the foot of the sail should be fairly slack to allow the sail to belly out; but in strong winds the foot should be hauled out fairly taut.

The fore sheets are rove through eyebolts fitted to each gunwale, and thence to jamming cleats fitted on each side of the stern-sheets. Two fairleads abaft the fore-sheet fairleads are provided for the sheets of the Genoa jib.

The main sheet is a jigger, the standing block of which is shackled to a ring in the floorboards of the stern-sheets, and the other to a strop on the boom whence the hauling part is led round a cleat on the floorboards and tended. The storm trysail is fitted with separate sheets, the blocks of which are hooked to eyes on the quarter bollards.

The centre-plate is raised and lowered by a small tackle on the starboard side of the keel-box.

Negotiating a surf

The chief dangers to a boat in surf are that a wave may break inboard, and that the boat may be carried shoreward out of control by the surf.

As a boat can manoeuvre more easily, move much faster, and accelerate much more quickly when going ahead than she can when going astern, surf should always be negotiated with the boat's bows pointing seaward, even when landing; she can thus be pulled quickly over a threatening wave, or pulled seaward vigorously to avoid riding either on the crest of a wave or in surf. Backing a boat shoreward through surf may be more tiring than pulling her, but she is always helped on by the general movement of the sea shoreward. Additional advantages of keeping the boat heading seaward are that:

1. The coxswain is always facing the direction from which danger threatens.
2. At the critical moment when the bows lift to a wave the steer oar is deeply immersed, thus ensuring full control of the boat.
3. There is less chance of the steer oar being wrenched from the coxswain's grasp and knocking him overboard.
4. The oarsmen are not distracted by oncoming breakers.
5. A transomed boat is less liable to yaw or broach to.

Each occupant of the boat should wear a self-inflating lifejacket or, if this is not available, a General Service lifejacket inflated as fully as the duties of the wearer allow. If the boat capsizes the occupants should immediately try to get to seaward of her to avoid being crushed by her pounding on the bottom, and from this position they can help to guide the boat as she is carried shoreward by the surf.

The coxswain should sit or stand where he can see over the heads of his crew. His orders to the crew should be short and sharp, and they should be obeyed instantly. If, for example, the crew are holding water and the order 'Give way', or 'Back', is given, the crew should give a half-stroke before their first full stroke in order to get way on the boat immediately.

Before each wave approaches, the boat should always be pointed at right-angles to the line of the waves, and any tendency she may have to slew to one

side or the other should be countered immediately by the steer oar. When landing through surf (stern first, as directed) the stroke oarsmen should keep a lookout astern.

Before negotiating a surf the coxswain should carefully survey it from seaward of the first line of breakers when landing, and from the highest vantage-point ashore when putting to sea, to enable him to select the most favourable place. He should note the extent of the surf, the length and height of the seas, the interval between them, the extent and duration of the calm and rough periods, the direction and effects of any cross-swell, the state of the tide, the gradient of the beach, the positions of any reefs, rocks or shoals, the extent of the danger area, and the probable effect of wind, current or tidal stream on his course. Before leaving the ship the coxswain should also examine the largest-scale chart, the appropriate volume of the *Admiralty Sailing Directions* and the *Admiralty Tide Tables*, and also obtain any local information that is available.

Having selected the *best position* from which to enter the surf, he should select the *right moment* at which to enter it. If entering from seaward, this will be on the heels of the last of a series of high waves, so that he will, if possible, be able to cross the danger area in a calm period; if entering from the shore, it will be immediately after such a wave has broken on the beach, so that the ensuing calm period will give him time to make a good offing before the next high waves approach.

The use of a warp to haul a boat through surf, either seaward or shoreward, is not recommended, because it restricts the movement of the boat, its weight tends to immerse deeper the end of the boat to which it is secured, and it may prevent her escaping from a breaker or drag her into one.

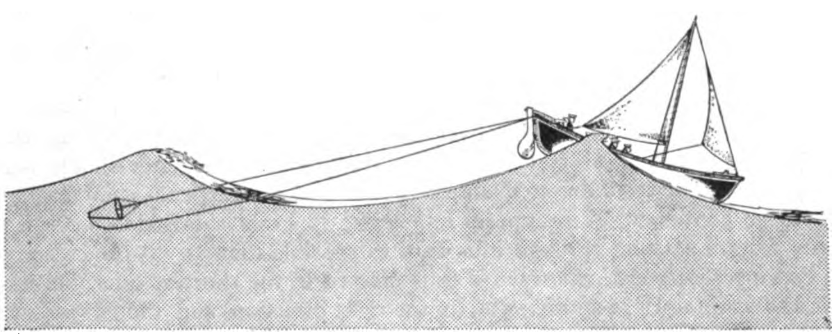


FIG. 8–18. Use of a drogue when running before a heavy swell

A drogue should always be used when pulling or running before a heavy swell or sea, because it keeps the stern of the boat to the waves and prevents her from sheering to either side of her course and from riding on the crest of a wave (fig. 8–18). When landing through surf, however, the advisability of using a drogue depends upon the type of boat and the nature of the surf. It is most useful for the larger power-driven craft, which can be taken in bows first to the beach, but if used for a small lightly-manned pulling boat it is likely to hamper her manoeuvrability.

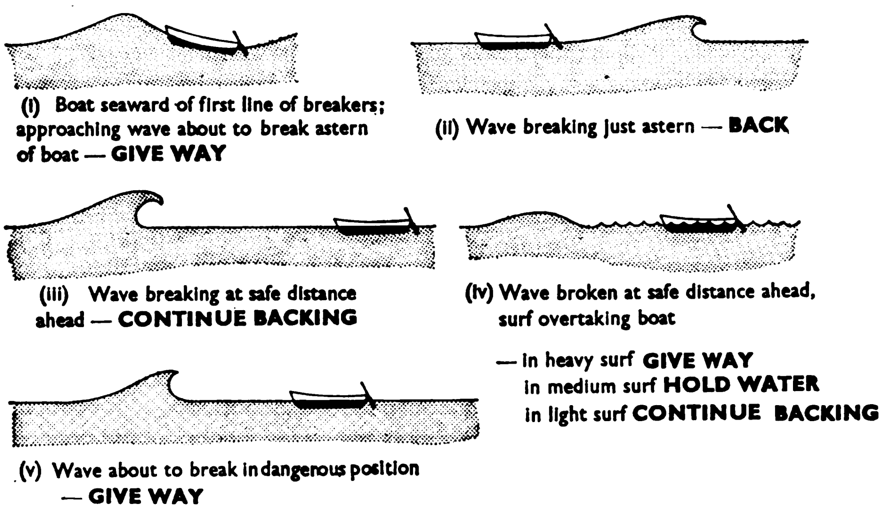


FIG. 8–19. Going shoreward through surf

Procedure for landing in a surf

The coxswain should cruise seaward of the outer line of breakers, select his point of entry into the surf, and then turn the boat stern to shore and at right-angles to the waves and keep her there until a favourable opportunity occurs for crossing the first line of breakers. Just before the start of a relatively calm spell he should back his boat smartly so as to enter the danger area on the heel of a wave, and then continue his progress shoreward by backing, but resting on the oars and holding water or giving way, as required, to avoid a breaking wave or being carried along either on the crest of a wave or in surf.

The best position for a boat in relation to a breaking wave is at least two boat's lengths ahead of it. The boat should continue backing until the surf reaches her, when, to avoid being carried along with it, her crew should hold water or give way according to its intensity; then, when it expends itself, backing should be continued. If it appears impossible to avoid a breaking wave it is better to pull seaward through it as hard as possible than to try to escape it by backing shoreward; the wave is thus crossed in the shortest time, the boat should remain upright and pointing in the right direction, and, though she may be swamped, her reserve of buoyancy will keep her afloat: whereas, if backed, she will be carried shoreward out of control by the surf and will probably broach to.

Beaching

In light surf with only small waves breaking close inshore, as will often occur at or near the time of low water, the boat can be beached more deliberately than in a heavy surf at high water when there may be only one line of breakers of dangerous proportions and the boat must be beached and hauled clear of the breakers as quickly as possible. The two different procedures are described below.

Light surf on a gradually shelving shore. On reaching shallow water the cox-

swain boats his steer oar, and he and the two stroke oarsmen jump out and hold the stern to the beach while the remainder of the crew continue backing and keep the bows on to the waves. As the boat grounds, the coxswain orders the crew to get out smartly, in pairs from aft forwards, the bowmen being the last to leave; then, seizing the gunwale, the crew haul the boat clear out of the water.

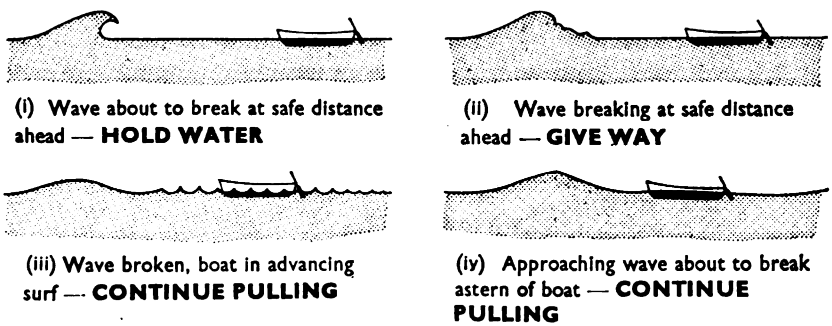
Heavy surf on a steeply shelving shore. Under these conditions the line of breakers must be crossed and the boat beached in the shortest possible time, not only to avoid the breaking waves but also to avoid the strong undertow. As before, the coxswain should turn the stern to shore, and when a favourable opportunity occurs the boat must be backed smartly inshore on the back of the last of a series of high waves. Immediately the boat grounds the coxswain orders the whole crew to jump out and haul the boat clear of the water as quickly as possible. If the boat is not hauled up before the next wave breaks there is a chance that both boat and crew will be dragged into it by the undertow.

Putting to sea through surf

The boat is prepared for launching by shipping the oars in their crutches and laying them athwart the gunwales. The crew then station themselves round both sides just before their thwarts, grasp the gunwale, and haul the boat to the water's edge, bows seaward.

Light surf on a gradually shelving shore. When an opportune moment occurs the crew launch the boat smartly by order from the coxswain, and as soon as she is afloat the coxswain orders the bowmen into the boat. They jump in, man the oars, and keep the bows pointing seaward. Then in quick succession the coxswain orders the remainder of the crew into the boat, in pairs from forward aft, and as each pair jumps in they man their oars. Finally, the two stroke oarsmen and the coxswain jump into the boat, and she is pulled smartly seaward. In practice the stages of this operation are carried out rapidly one after the other.

Heavy surf on a steeply shelving shore. The boat must be launched between two successive waves and pulled seaward of the line of breakers before the oncoming wave breaks. The coxswain should wait for a calm spell and then launch his boat immediately a wave breaks. The crew then run the boat as fast as possible into the surf, jump into her together as soon as she is well afloat,



(i) Wave about to break at safe distance ahead — **HOLD WATER**

(ii) Wave breaking at safe distance ahead — **GIVE WAY**

(iii) Wave broken, boat in advancing surf — **CONTINUE PULLING**

(iv) Approaching wave about to break astern of boat — **CONTINUE PULLING**

FIG. 8–20. Going seaward through surf

and immediately get their oars out and pull seaward as hard as possible, without further orders, until the boat has crossed the line of breakers.

When pulling seaward through surf the coxswain must judge accurately where the next wave is going to break and manoeuvre his boat so that she either crosses the wave before it breaks or is two or three lengths shoreward of the wave when it breaks.

Surf-riding

The term *surf-riding* is used to describe both riding a boat on the crest of an unbroken wave and riding her on the surf of a broken wave. It is dangerous unless carried out by experienced men in special craft, but in special circumstances it may have to be done in order to cross a stretch of water quickly or land quickly through surf; in the latter case the momentum gained by riding on the crest of a wave is used to carry the boat through one, or at the most two, lines of breakers on to the beach or over a reef into a lagoon.

For surf-riding a boat should be light, have fine lines, be very buoyant forward, decked in aft, and trimmed so that her centre of gravity lies at one-third the length of the boat from the stern. Instead of oars she should have a double bank of paddles, which are easier to handle and have a better grip in surf because they can be dug deeply into the water.

To surf-ride on a wave the boat must be given sufficient initial momentum to place and keep her on its front slope, with her stern just below its crest. In this precarious position the boat is forced through water at the speed of the wave, which can be as great as 15 knots, and the slightest yaw to either side of her course at such a speed, unless immediately countered, will slew the boat so that she broaches to and capsizes. There is also the danger of the weight of the boat causing her to over-run the swell and dig her bows into the trough, which may well broach her to or upend her. Her crew must therefore endeavour to keep the boat balanced on the forward slope of the wave, and the coxswain must immediately correct any tendency to yaw. If the wave overtakes the boat no harm will result provided that the coxswain can keep her from slewing off her course.

LANDING ON A ROCKY SHORE

Men can be landed on, or embarked from, a deeply shelving rocky shore in weather suitable for boatwork if the landing-place is clear of surf and it has a good approach from seaward. (As used here, the word 'surf' means that caused by waves breaking before they reach the shore, and not the froth caused by waves breaking on it.) The most suitable boat for this operation is a double-ended power boat with good astern power and manoeuvrability. A strong warping bollard should be fitted in her stern, and she should carry an anchor with good holding-power and a warp of sufficient length (for depths of up to 3 fathoms a 20-fathom warp is required).

The anchor is dropped, as a kedge, to seaward of the selected landing-place and within warping distance of it, and the boat is then run in to the landing-place while the warp is paid out astern. The final stage of the approach is made cautiously, with the warp kept taut, until the bows are two or three feet from

the shore. The warp is then belayed and the boat kept in position by running the engines slow ahead. The bowman then jumps ashore and keeps the bows steady with the painter, and the passengers then jump ashore (or on board), timing their jump with the scend and surge of the boat. When the embarkation or disembarkation is completed the boat is warped astern to the anchor, which is then weighed.

The best conditions for this operation are when the sea or swell is heading directly towards the landing-place, so that the boat can approach with it directly astern of her, and landing should not be attempted if the angle between the line of the shore and the direction of sea or swell is less than 45°. Wind and tidal stream or current and outlying rocks may affect the selection of the line of approach, but it should be clear of rocks to avoid fouling the warp and should be as nearly down sea or swell as is practicable.

Before the anchor is let go a bight of its warp equal to the depth of water must be streamed to ensure that the anchor drops straight to the bottom. When half-way between the position of the anchor and the landing-place the hold of the anchor should be tested; if it comes home it must be weighed and dropped again in another place. The longer the scope of the warp the better will the anchor hold.

BOARDING

Vessel at sea

The vessel to be boarded will probably make a lee for the boarding boat by lying hove to with the wind and sea at some point between abeam and broad on the bow, as best suits her. The boarding vessel will probably lower and slip her boat in the other vessel's lee.

A ship should almost always be boarded on her lee side, and the best position is where her freeboard is lowest and as near amidships as possible, where the vessel's pitching and yawing will be least felt. When boarding an 'island freighter' the best position will be abreast the fore end of her after well-deck, or the after end of her fore well-deck, according to whether she is lying with her bow or quarter to the sea. On no account should an attempt be made to board a ship's weather side, because the seas will fling the boat against it and probably smash or swamp her. If the ship is lying beam on to the sea there will probably be a considerable swirl and backwash round her bows and stern; and if lying with the sea on her bow and pitching, there will probably be a considerable swirl and undertow at her bows and especially at her stern: a boat should therefore always give a wide berth to the bows and stern of a vessel hove to. If the ship is using her engines to keep steerage way, as wide a berth as possible should be given to her propellers, especially ahead of them, as otherwise the boat may be drawn into their wash and swamped.

The vessel being boarded should provide fenders lowered to the waterline, a jumping ladder and lifeline, and a long boatrope which should have a long eye spliced in its end and be led well forward so as to allow the boat to rise and fall on the waves independently of the ship. While the boat is alongside a hand should be stationed in her bows to slip or cut the boatrope immediately should the need arise.

Some ships, particularly coasters and short-sea passenger liners, are fitted with a rubbing strake which projects from the ship's side just above the waterline and constitutes a serious menace to boarding-boats. The best way of fending the boat off such ships is by oars or spars held vertically between the boat and ship's side so that the side of the boat rides on the oars or spars as she rises and falls and the gunwale cannot get under the rubbing strake.

By liferaft. When weather conditions are too bad for boatwork a liferaft can be used, in the manner described in Chapter 11.

A wreck

Unless bows or stern on to wind and sea, a stranded ship affords a good lee for a boat and should be boarded on her lee side if clear of wreckage and the depth of water allows; if not clear, it may be possible to board her over her bows or stern. If the only possible approach is from windward it may be possible to get within heaving line distance by anchoring the boat some distance to windward of her and then dropping down on her by veering cable.

If there are signs of panic or disorder on board the wreck the boat should not attempt to go alongside, but should lie off, stern on to the wreck, and haul survivors to the boat one by one on a line.

SWEEPING FOR LOST OBJECTS

Locating something on the bottom by sweeping in order to recover by diver is not a difficult operation if the approximate position is known and the sweeping operation is properly carried out. The method advocated here is effective for any sunken object large enough to be 'felt' on the sweep wire.

Preparation

The following information must be obtained:

- description and weight of object
- nature of bottom
- depth
- direction and strength of current or tidal stream, times of high and low water, and range of tide
- direction of wind
- transit marks or any other information to establish approximate position.

The following equipment is required:

- chain sweep
- marker buoys with sinkers ready for streaming
- stops, strops and securing lines
- sword matting or chafing pads
- 20-ton screw bow shackle
- 30 fathoms of 1-in. manila
- axe
- leather gloves
- radio
- first aid outfit

Sweep. It is recommended that the sweep should be made up as in fig. 8–21, which will be effective in depths of as much as 20 fathoms in a tidal stream of up to nearly 3 knots.

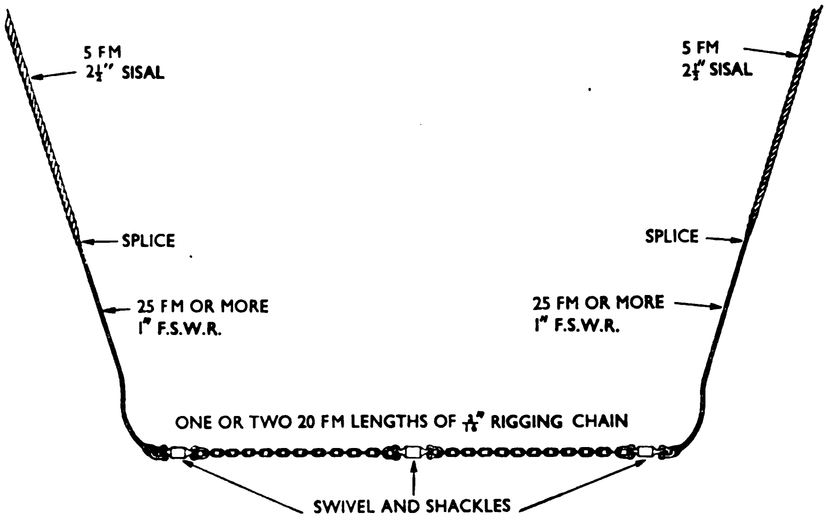


FIG. 8–21. Diagram showing component parts of the sweep

Marking the position

It is assumed that the approximate position is known. If it is not already marked, a buoy must be laid as the datum sweeping mark.

Sweeping

Boats work in pairs, that in which the sweep is carried being called the 'working' boat and the other the 'non-working' boat. Both boats should stem the tidal stream (or wind and sea) well above the mark buoy, and one end of the sweep should then be passed to the non-working boat. In each boat the tail of the sweep should be secured to a cleat on her outer bow and then be led round her bows and along the gunwale to her inner quarter, care being taken to stop the tail clear of the water and of the boat's propellers (fig. 8–22(i)). The bight of the sweep should then be paid out over the stern of the working boat, being checked as necessary to prevent the chain of the sweep from fouling itself.

The boats should then turn round to head downstream, open out to the effective limit of the sweep, and proceed slowly downstream at slow speed so that the sweep will not dislodge or underrun the object. When the feel of the sweep indicates an obstruction both boats should stop their engines and turn sharply inward so that the stream will sweep their sterns round and the boats be brought alongside each other heading upstream (fig. 8–22(ii) and (iii)). During this manoeuvre the stops on the sweep tail in each boat should be cut so that it will stream clear of her side.

The working boat now takes both ends of the sweep over her bows and proceeds slowly towards the position in which the obstruction was located, the slack of both parts of the sweep being taken down by hand. When nearly over the located position, a 20-ton bow screw shackle, tailed with 30 fathoms of one-inch manila messenger, should be shackled round both parts of the sweep

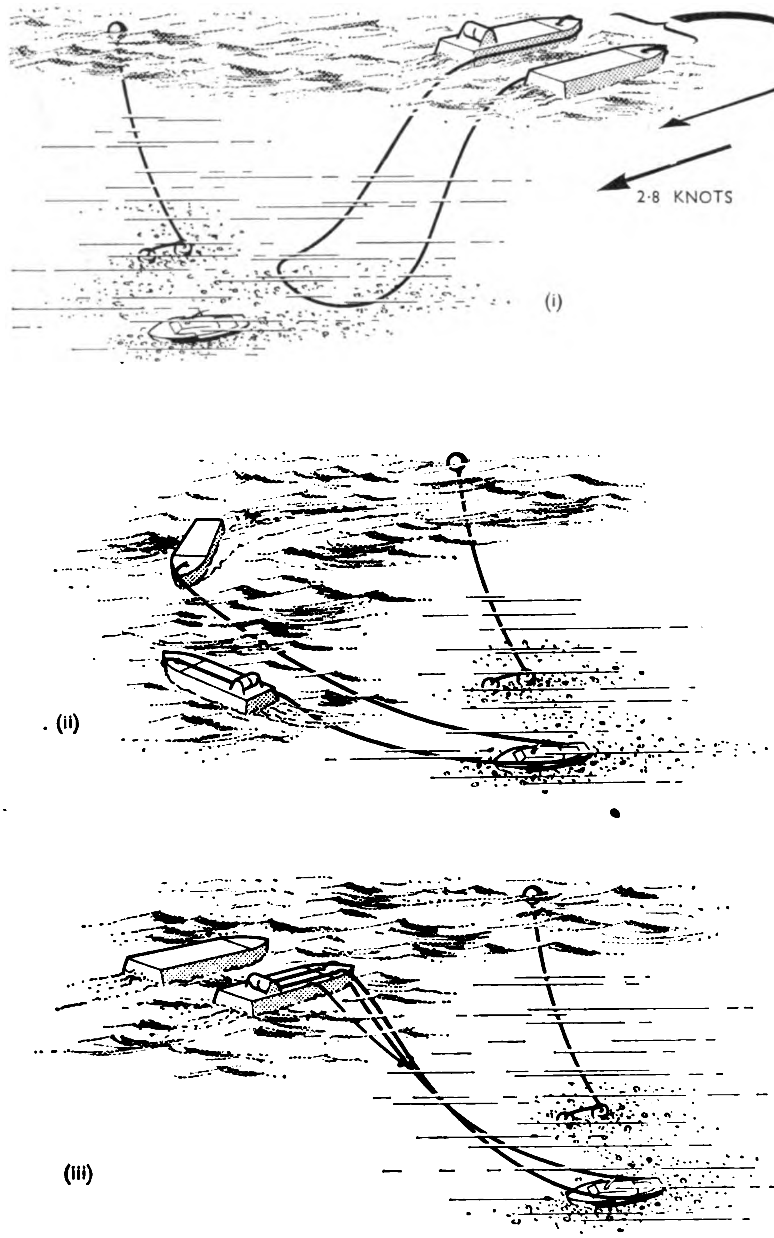


FIG. 8–22. Sweeping downstream with two boats

and lowered to its full extent (fig. 8–22(iii)). This operation must be carried out very carefully so as not to dislodge the bight of the sweep. If the object cannot be lifted by the boat, or if it appears doubtful that the sweep will hold it, the position should be buoyed immediately.

Sweeping against the stream. The disadvantage of sweeping against a tidal stream or current is that the sweep chain tends to lift instead of biting into the bottom, and may ride over any obstruction. The sweep is carried out as already described except that the stream is stemmed, and when the sweep catches in the object the boats are turned inward, but one passes inside the other, as shown in fig. 8–23(i); and they are then manoeuvred together downstream from the object.

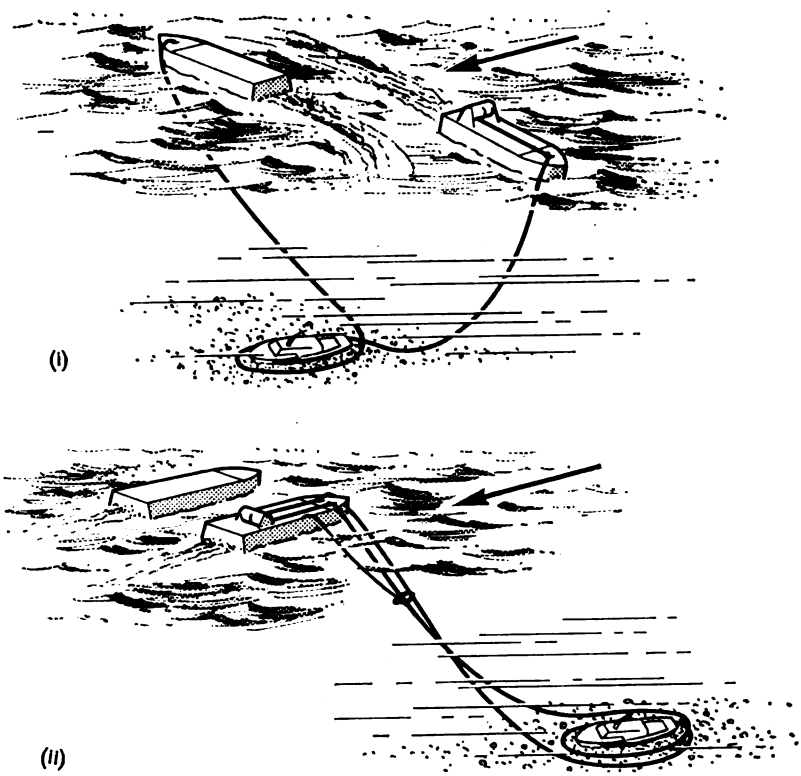


FIG. 8–23. Sweeping upstream with two boats

Single boat sweep. A grapnel sweep can be used with good results at slack water if the sea is calm. The grapnel should be tailed with about 200 fathoms of $\frac{3}{4}$-inch F.S.W.R. reeled on a small cable drum. It should be lowered to the bottom near the object, and the boat then steered round it while the greater part of the wire is paid out (fig. 8–24). When sufficient turns have been laid round it any slack is taken in by hand and the weight of the boat is then used to tauten the turns.

FIG. 8–24. Sweeping with one boat

SUPPLY, EQUIPMENT, MAINTENANCE, REPAIR AND BUOYANCY OF BOATS

SUPPLY, FITTING-OUT AND SPECIFICATIONS

When a ship's boat is supplied by the Naval Store Officer of a dockyard she is provided with only those items of hull equipment and rigging which are peculiar to that type of boat. When received by the ship she must be equipped for sea service with standard naval stores, the quantity and type depending on the type of the boat and the purposes for which she is to be used. She must also be fitted with her slings.

Supply of pulling and sailing boats

A pulling and sailing boat is supplied with all hull fixtures, masts and spars, sails, sail covers, rigging, and portable equipment such as rudder, tillers, yoke and yoke-lines, stretchers and their fittings, bottom boards and gratings and their latches, towing bollard, shutters, strongback (if bower anchor can be taken away), ensign and pendant staves, bearing-out spars, awning with battens (only to ships on service in hot climates), and painter.

The masts, spars, sails, rigging and portable hull equipment are listed in the *Boat's Equipment List*, and this list, together with equipment listed on it, should accompany the boat whenever she is transferred or returned to store.

Supply of power boats

A power boat is supplied with all hull fittings and portable hull equipment such as awnings and their covers, stanchions, canopies, curtains, cushions, furniture, ladders, and brackets and screens for navigation lights. These are listed in a printed pamphlet called the *Boat's Fixture List* and are taken on charge by the Shipwright Officer. This list and the equipment listed in it should accompany the boat whenever she is transferred or returned to store. Details of any rigging supplied with the boat are included in the *Ship's Rigging Warrant*.

A power boat is also provided with an *Engineer's Spare Gear List* (Form D 787), which gives the details of the engines and spare gear with which the boat is fitted. Two lists of spare gear are provided for each engine, one being held by the Naval Store Officer of the dockyard and the other by the Engineer Officer of the ship; the latter list should accompany the engine whenever it is removed from the boat and transferred ashore or to another ship.

Fitting out pulling, sailing and power boats

When the boat is drawn from store it must be fitted out in the ship with Naval stores to the scales shown in the tables on pages 292–295, and with the following miscellaneous Naval stores:

bailer
boat's cover
boat-hooks
boxes of canned water and/or jerry-cans
cable punch (if fitted with chain cable)
compass
crutches and oars
ensign and pendant
fenders
fire extinguishers (one for each 16-ft power boat, two for each power boat of more than 16 ft)
klaxon horn (if a power boat not otherwise equipped for sound signalling)
funnel, 3-quart size (if a power boat)
oil lantern (or a candle lantern and candles if a pulling or sailing boat)
navigation lights (if a power boat)—i.e. a starboard light and a port light (or a combined port and starboard light), a steaming light and an overtaking light
lead and line (boat's)
lifejackets (one for each member of the crew and one spare)
lifebuoy (if a power boat)
reel for boat's cable (if a cable locker is not provided)
rescue quoit and line
lumber crutches (for launches, pinnaces and 27-ft surf boats only)
reel for a small wire hawser (launches and pinnaces only)
a copy of the *Minor Landing Craft and Boat's Signal Book*, a hand answering pennant and a pair of hand semaphore flags
signal flags and a wallet (if a power boat equipped with a signal mast)
boat's bag, carpenter's bag and boat's distress signal box (for contents, see Volume I)

Fitting slings to boats

When any boat is supplied to a ship she is fitted with her sling-bolts or plates and with the slings peculiar to her type and the method by which she will be hoisted and lowered. Details of the slings for every ship's boat are given in the *Rigging Warrant*. Boats hoisted at davits are provided with a Robinson's hook, and if seaboats they are equipped with Robinson's disengaging gear.

PARTICULARS OF

Type of Boat	Breadth (extreme excl. rubbers)	Rig and Class Symbol/letter	Sails: Dimensions (fully stretched)	Head	Foot	Luft	Leach	Diag.	Bunt	Area	Reefs
Pulling and Sailing	ft in.			ft in.	ft in.	ft in.	ft in.	ft in.	ft in.	sq. ft	No.
32-ft Sailing cutter (drop keel)	8 6½	Sloop DZ	Fore	—	10 0	18 3	14 6	—	—	79	2
			Main	20 4	18 6	8 4	30 3	19 8	—	299	3
			Storm F.	—	6 6	11 0	7 9	—	—	27	3
			Storm M.	—	17 0	17 0	21 4	—	—	154	—
27-ft Whaler (drop keel)	6 0	Yawl K	Fore	—	6 3	11 3	9 8	—	—	33	1
			Main	14 4	12 6	6 2	21 2	13 10	—	148	2
			Mizzen	—	6 6	9 6	10 0	—	—	32	—
			Storm F.	—	12 0	11 3	15 0	—	—	71	—
27-ft Surf boat (drop keel) (Surveying Vessels)	6 1½	Gunter	Fore	—	8 0	16 6	13 6	—	—	56	1
			Main	12 8	12 9	9 6	22 6	—	—	154	2
			Storm F.	—	5 9	13 0	9 0	—	—	22	—
			Storm M.	—	12 3	14 6	18 7	—	—	88	1
14½-ft Surf boat (drop keel) (Surveying Vessels)	5 0	Lugsail	Main	10 6	9 3	4 10	16 3	—	—	70	2
14-ft Sailing dinghy (drop keel)	5 4¾	Gunter RN	Fore	—	5 2	12 3	11 1	—	—	29	1
			Main	14 6	10 1	5 4	21 2	10 11	—	108	(roller)
10-ft Pulling and sailing dinghy (with dagger plate)	4 3	Standing Lugsail	Main	9 0	7 0	3 0	11 8	—	—	50	—
27-ft Motor whaler	7 0	Gunter L	Fore	—	7 8½	18 6	15 9½	6 9	—	63	
			Main	18 2½	12 5	10 0	30 5	16 0	—	195	(roller)
			Genoa	—	13 1	18 6	18 2½	12 6	—	119	
			Spinnaker	—	14 0	—	20 8½	—	21 9	270	
14-ft G.R.P. Sailing dinghy 'Bosun'	5 6	Bermudian Boatswain's call	Fore	—	5 0	13 0	12 3½	—	—	30½	
			Main	—	9 0	18 7	20 2½	—	—	84½	
			Spinnaker	—	9 7	—	13 8½	—	—	110	
Pulling											
17½-ft Boom boat (Boom Defence Vessel)	7 3	No sailing gear provided									
14½-ft Drifter boat (Drifters)	5 9	No sailing gear provided, but in certain circumstances may be provided with an outboard motor.									
Collapsible dinghies:											
12-ft	4 6¾	Dimensions folded: 12ft × 3ft × 1ft 4in.									
10-ft	4 1¾	10ft × 2ft 10in. × 1ft 10in.									

SERVICE BOATS

Masts and Spars (Dimensions of yards are from inner edges of holes at throat and peak): Masts	Spars	Ground Tackle: Anchor	Cable: Rope	Cable: Chain	Painter Rope	Oars	Water: Boxes of canned	Water: Jerry cans	Lifting Weight (No. of men in brackets)	Carrying Capacity
Length Diam.	Length Diam.	A.P.	Size Lgth	Size Lgth	Size Lgth	No. Lgth	No.	No.		
ft in. in. 23 2 5	ft in. in. Yard 20 6 3⅞	lb 40	in. fm 3 25	in. fm 5/16 5	in. fm 3½ 8	ft. 8 15 4 14	—	2	cwt 52(2)	men 29
Main 16 6 3⅜ Mizz. 13 6 2⅝	Yard 14 5½ 2½ Boom 6 10 2	30	2½ 20	¼ 5	3 7	4 17 1 16	4	2	26(2)	15
(hollow)20 10 3 5/16	Gaff 12 8 2⅜ (hollow) Boom 14 0 2⅞	30	2 50	— —	3 7	2* 17 5 15 4 14 10† 12	4	2	26(2)	15
12 0 2½	Gaff 11 0 2⅜ Boom 10 0 2¼	20	2 30	— —	2½ 4	1* 10 6† 8			8(2)	7
14 6 3	Gaff 15 0 2¼ Boom 10 8 2¼	20	2 20	— —	2 4	4 8			10(2)	6
9 6 2⅜	Yard 9 6 2¼	10	1½ 20	— —	2 6	2 8			4(1)	3
23 2 4⅛	Yard 18 9 3 Boom 13 2 3×3	30	2½ 20	¼ 5	3 6	5 17	4	2	50(4)	23
21 8	Boom 9 3⅛	—	—	—	—	—			3½	
		30	2½ 25	¼ 3	3 5	2 8 4 10 2 14			45(2)**	13
		20	2 20	— —	2 4	2 10 2 14			10(2)	7
					2 3 2 3	2 8½ 2 8½			5(1) 4(1)	4 2

Note: The numbers in the last column represent the normal carrying capacity of each boat in calm weather. The numbers should be reduced at the discretion of the Officer of the Watch, or the person in charge of the boat, according to the weather and the nature of the duties to be performed. The weight in tons which can be carried can be calculated by dividing the carrying capacity by 14 (on the assumption that the average man weighs 160 lb), but it is emphasised that if cargo is carried instead of men it must be as low as possible in the boat and never athwart or above the gunwales.

* Steering oars † Surf oars ** Includes special equipment.

PARTICULARS OF

Type of Boat	Breadth (extreme excl. rubbers) ft in.	Speed (approx.) knots	B.H.P. (approx.)
Round Bilge (slow and medium speed)			
1. 45-ft† Medium speed picket boat	10 6	13	170
2. 45-ft Motor launch (M.L.)	11 6	8	35 or 65
3. 36-ft Work boat	10 5½	8	91
4. 36-ft Motor pinnace (M.P.)	9 9	8½	43
5. 35-ft† Medium speed motor boat (M.S.M.B.).. ..	9 2	12	144
6. 32-ft Motor cutter (M.C.)..	8 6½	7½	43
7. 27-ft Motor whaler (M.W.)	7 0	6½	11½
8. 25-ft Motor cutter (M.C.)..	7 0¾	6½	11½
9. 25-ft† Medium speed motor boat (M.S.M.B.).. ..	8 0	10	65
10. 16-ft Slow motor boat ..	5 7½	6	5½
11. 29-ft Motor surveying boat	8 3	7½	43
12. 28-ft Motor surveying boat	7 6	7½	25
13. 16-ft Motor surveying boat	5 5	6	7
Hard Chine (fast)			
15. 45-ft† Fast motor boat ..	10 6½	16	195
16. 35-ft† Fast motor boat ..	8 10½	17	130
17. 30-ft† Fast motor boat ..	8 0	13/16	100
18. 25-ft† Fast motor boat ..	7 0	13	65
Gemini Craft (inflatable)			outboard
20. Gemini Medium	6 10	18**	40/18

* Comprises 3 fathoms at the inner end and 5 fathoms at the outer end.
** With one man.
† May be equipped as Flag Officers' barge.
†† Weight 132 cwt when carrying 6 men and surveying equipment.

Note: The numbers in the last column represent the normal carrying capacity in calm weather. The numbers should be reduced at the discretion of the Officer of the Watch, or the person in charge of the boat, according to the weather and the nature of the duties to be performed. The weight, in tons, which can be carried can be calculated by dividing the carrying capacity by 14 (on the assumption that the average man weighs 160 lb); but it is emphasised that if cargo is carried instead of men it must be carried as low down in the boat as possible, and never on the deck.

SERVICE POWER BOATS

	Ground Tackle						Water		Lifting Weight (No. of men in brackets)	Carrying Capacity
	Anchor		Cable							
	A.P.	C.Q.R.	Rope		Chain		Boxes of canned	4½-gal. jerry cans		
			Size	Lgth.	Size	Lgth.				
	lb	*lb*	*in.*	*fm*	*in.*	*fm*			*cwt*	*men*
1.	—	53	3	35	7/16	8*	4	3	193(4)	50
2.	—	72	3½	35	⅜	8*	4	3	198(4)	105
3.	—	53	3	25	7/16	5	3	—	143(3)	70
4.	—	53	3	35	7/16	8	4	3	143(4)	52
5.	—	26	2½	25	¼	5	3	3	127(3)	30
6.	40	—	—	—	7/16	40	4	3	95(6)	31
7.	30	—	2½	20	¼	5	4	2	50(4)	23
8.	—	26	2½	25	¼	3	3	2	50(2)	26
9.	—	26	2½	25	¼	5	—	—	67(3)	20
10.	—	15	2	20	—	—	2	—	22(2)	8
11.	50/53	—	—	—	⅜	30	—	—	102(3)††	20
12.	50/53	—	—	—	⅜	30	—	—	102(3)††	20
13.	—	15	2	25	—	—	—	—	22(2)	7
15.	—	41	2½	25	¼	8*	—	—	175(4)	55
16.	—	26	2½	25	¼	5	3	3	101(3)	40
17.	26	—	2½	25	¼	5	3	3	72(3)	30
18.	—	26	2½	25	¼	3	3	2	50(2)	18
20.									*lb* 400	10

Port Auxiliary Craft Carrying Capacities

	men
90-ft Motor fishing vessel	270
75-ft Motor fishing vessel	200
75-ft Fleet tender	200
72-ft Hospital launch	140
61½-ft Motor fishing vessel	130
52½-ft Harbour service launch	75
45-ft Motor fishing vessel	90
45-ft Motor passenger launch	60
36-ft Harbour launch	52

MAINTENANCE OF HULLS

The causes of deterioration leading to defects and leaks in wooden craft are generally due to one or more of the following causes: rot, shrinking, warping and splitting; structural deformation; electro-chemical action; and parasitic attack.

Rot

Untreated non-durable woods are subject to rot caused by moulds which feed on the wood in the presence of oxygen and moisture (e.g. rain water and condensation). It is most common near deck level and in dead air spaces such as bilges, buoyancy-chambers, chain-lockers and other lockers that may be used for the stowage of wet gear. It can be prevented by thorough drying of the boat and its gear, stopping all leaks, and thorough ventilation.

Shrinking, warping and splitting

When wood is too dry it tends to shrink, warp and split, allowing moisture to enter crevices and to start rot. When boats are laid up ashore or stowed on board they should be covered to protect them from the heat of the sun, and they should be partly filled with salt water at regular intervals. Any shakes or open joints should be stopped with white lead, and the paint coating must be kept in good condition.

Structural deformation

A boat at davits or in crutches may be deformed if it is overloaded or inadequately supported. It can be avoided by using the correct slings in the right way, by pitching a boat properly in her own crutches and by keeping out loose gear and bilge water. If a boat has to be given a temporary stowage, make sure that the keel is supported on chocks, especially beneath engines, and that the bilges are supported by high-lows. If the boat is large, shores must be placed under the rubbers.

Seaboats must not be too tightly griped.

Electro-chemical action

When two dissimilar metals are immersed in salt water a chemical action is started which causes a softening of the wood round metal fittings and fastenings called 'nail sickness'. The effect can be reduced by keeping the bilges dry and the stopping in joints and over nailheads and the protective paint coatings in good condition.

Parasitic attack

Wooden boats are attacked by wood-boring parasites, especially in tropical waters. The teredo worm tunnels into and honeycombs the wood, and the gribble crab digs a shallow tunnel to form a cave-home for itself. Sheathing is the only sure method of protection; but slipping and drying, or immersion in fresh water for 14 days, kills the infection.

CARE OF SAILS

Boats' sails must be carefully handled and looked after; otherwise they will set badly and be inefficient. The bending on and stretching of a new sail is particularly important, because it can be ruined by wrong treatment.

A sail is cut and sewn to exact measurements which allow for the initial stretch, which must be uniform and not excessive. Once a sail has been stretched it is not very elastic and can easily be permanently distorted when drenched by rain or spray unless the clew or peak earings and the lacing of the boom, gaff or yard are eased away and the halyards settled to ease the strain in the luff and leach.

Cotton sails

Stretching. Choose a fine sunny day when the breeze is light or moderate. Never set a new sail if it is blowing hard, or if it is damp or raining. Hoist away on the luff until it is fairly taut, but no more. Pull the sail out on the boom until the small wrinkles along the foot just disappear. When hoisting sail, take the weight of the boom on the topping lift until the sail is hoisted all the way up.

With the sail properly set, get under way and sail for about an hour, preferably without a headsail. Try to keep the whole of the sail full and drawing at this stage. It will soon become apparent that the luff and foot ropes are stretching by the appearance of sags and wrinkles. As this stretching takes place, haul on the halyard and clew an inch or two at a time. In sails fitted with a wire luff there is, of course, no need for gradual stretching and the sail can be set up taut right from the start.

Washing. Dirty sails should be washed in fresh water and soap and then dried before being stowed; if necessary, they can be lightly scrubbed. Salt-encrusted sails should be thoroughly rinsed out in fresh water. Large sails can be hosed down. To dry a sail, hang it up supported at intervals from a line by its longest roped edge, not the leech. Do not allow it to flap about.

Stowing. Preferably, sails should be unbent from their spars for stowage; if this is impracticable, the peak and clew earings and the lacings should be eased away before stowing. They should be perfectly dry, battens should be removed and the sails stowed in a clean, dry place. Metal fittings should not be stowed with the sails.

Mildew and rot. A wet sail should never be furled, since this will aid the growth of mildew on the surface of the fabric. Bundle the sail up very loosely so that air can circulate freely round it. Corners of sails take longer to dry out than the body cloths.

Nylon sails

Nylon is not affected by salt spray and has a very low water-absorption. Do not leave Nylon sails (such as spinnakers) exposed to the sun's rays for long periods of time, because sunlight weakens the fabric.

Terylene sails

Terylene sails also have a low water-absorption and do not shrink when wet. Resistance to mildew is high, and they stretch less than cotton sails.

Stretching. Pull the sail well out until wrinkles are removed, and after about an hour's sailing the sail should be ready for normal use.

Washing. These sails can be washed in the normal fashion, using a soap or soda solution or detergent, as hot as the hand can bear. At areas where the soiling is heavy, neat detergent can be applied and the sails left overnight before washing. If general soiling is persistent the sails should be steeped in a solution of sodium metasilicate (1 lb to every gallon of water). (Do not use a galvanised iron bucket or aluminium container for holding this mixture.) After this treatment the sail should be hand-washed and scrubbed lightly.

Removal of stains

(i) *Mildew*. There are certain species of bacteria that will grow on the surface of Terylene. Although the fabric is not damaged in any way, the unsightly mould stain should be removed. Scrub lightly with a stiff, dry brush to remove as much of the mould growth as possible; then steep the stained portion for two hours in a cold solution of 1 part 'Domestos' to 10 parts of water. Wash thoroughly in water and steep in a solution containing one part of sodium bisulphate to each thousand parts of water. Rinse finally with water. Repeat the treatment if necessary.

(ii) *Paint*. Dab the stain first with trichlorethylene and then with a mixture of equal parts of acetone and amyl acetate. Paint-strippers based on alkalis should *not* be used. Wash well afterwards.

(iii) *Metallic stains*. Stains caused by metals in the form of rust, verdigris or finely divided particles can be removed by either of the following methods:

(*a*) Immerse the stained part of the sail in a solution of 5 per cent oxalic acid dissolved in each pint of hot water. The hands and fabric should be well washed after using oxalic acid solutions, since this chemical is poisonous.

(*b*) Immerse in a hot solution containing 2 per cent hydrochloric acid in water. Rinse well after treatment.

(iv) *Pitch and tar*. Solvent naphtha, white spirit, or trichlorethylene may be dabbed on the stain to effect removal.

(v) *Varnish*. This can be removed in the same manner as for paint. Shellac varnish is easily removed with alcohol or methylated spirit.

(vi) *Grease, oil and waxes*. Small stains of this nature can be removed by dabbing with trichlorethylene, or by the use of proprietary stain-removers such as 'Coliclean'. Heavy staining is best removed by brushing on a mixture of detergent in a solvent. This can be prepared by dissolving one part of 'Lissapol' (NX) in two parts of benzene or toluol, or by brushing on 'Polyclens'. These solvent/detergent mixtures should be brushed well into the fabric, left for about 15 minutes, and then washed in warm water. A well-ventilated place should be selected for this treatment, and precautions should be observed if the solvents are inflammable. These treatments will remove oil, greases, Vaseline, lanolin and most lubricating mixtures; but they will not remove stains caused by fine metallic particles often associated with lubricants. These can be removed by the method described in (ii), (iii), (iv) and (v) above, after the oil or grease has been dealt with.

To bend a sail to a spar

The head of a mainsail is bent to a yard or a gaff by throat and peak earings and a lacing; the throat earing is the fixed anchorage and the peak the movable one. The foot of the mainsail or a trysail may be bent to a boom by tack and clew earings and also may be laced to the boom; the tack earing is the fixed anchorage and the clew earing the movable one. The earing has an eye spliced in one end and is secured to the sail by passing the other end through the cringle at the throat, peak, tack or clew, and back through its own eye. To pass a throat or tack earing, lay the boltrope next to the spar and reeve the earing through the hole or eyebolt in the spar and back through the cringle, and haul it taut; then take two or three turns round the spar and through the cringle and finish off with a clove hitch round all parts between the spar and the boltrope. To pass a clew or peak earing, reeve the earing through both the hole or eyebolt in the spar and through the cringle, and haul out the foot or head of the sail hand-taut; then take two or three turns round the spar and through the cringle, and finish with a clove hitch round all parts. The head or foot of a sail should not be hauled out too tautly along a spar, because then it would be unable to take up its natural belly and would thus be pulled out of shape; there should be about one inch clearance between the boltrope and the middle of the spar. When stretching new sails, the peak and clew earings require constant attention to take up any slack in the head or foot. In some mainsails bent to a boom the clew is fitted with a small tackle by which the foot can be hauled taut when beating and slacked off when reaching or running.

A sail may be laced to a spar by any of the three methods shown in fig. 8–25; but the direction in which it is laced is always from its throat or tack towards its peak or clew, and the lacing is secured to the throat or tack cringles in the same way as is the earing. The spiral lacing is best for the light sails of a boat, because it allows the head or foot of the sail to take up its natural set along the spar and any resultant chafe is negligible.

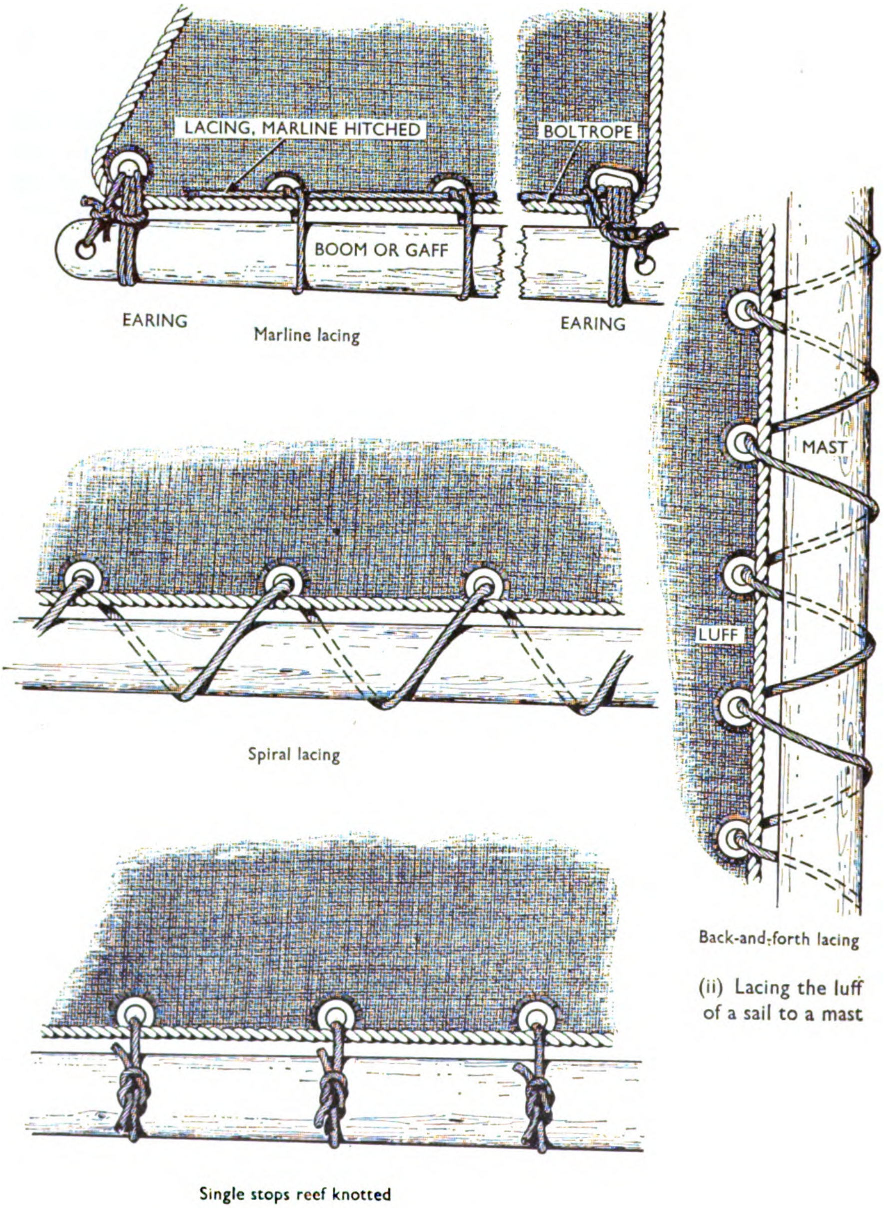
The heavier sails of larger vessels may be marled to their spars. In this method the head or foot of the sail is firmly secured to its spar and any tendency to chafe is minimised, but the whole lacing will probably have to be renewed if the lacing parts. For this reason many seamen prefer to bend heavy sails to spars by having for each cringle separate stops which can be quickly and easily renewed and which allow the sail a certain amount of play on the spar.

If the luff of a mainsail is laced to the mast the lacing should not be passed spirally round the mast, but 'back and from' the cringles round the fore side of the mast. If the lacing is passed spirally, or marline hitched, it will jam when the sail is hoisted or lowered.

Marking boats' sails

Service boats can be identified when under sail by black letters and numbers painted on canvas or calico (cotton sheet in motor whalers) sewn on each side of the peak of the mainsail at different heights and parallel with the gunwale. Dinghies' markings of black linen numbers are sewn straight on to the sail.

The marking consists of the distinguishing letter of the class of boat (followed by 1, 2, etc. if there is more than one of the class in the ship or establishment) or, if a dinghy, the boat's serial number. Underneath is the ship's pennant



(ii) Lacing the luff of a sail to a mast

(i) Bending the head or foot of a sail to a gaff or boom

FIG. 8–25. Bending a sail to a spar

number or the establishment's self-evident letter(s) or, if a dinghy, the last two numbers of the year of building. The following are examples:

Type of boat	*Ship or Establishment*	*Marking*	*Dimensions (inches)* Height	Width	Thickness of stroke
Cutter	St. Vincent's second	DZ2 V	21	7	3
Whaler	Royal Naval Barrack's first	K1 RNB	18	7	3
Motor whaler	Ajax	L F114	12	7	2
Dinghy		259 57	12	7	2
'Bosun' dinghy		Bosun's call number			

REPAIR

Damage to a boat's hull is made good by emergency, temporary, or permanent repairs, according to the time and facilities available. Any seaman should be able to effect a minor emergency repair; and though a temporary repair is a shipwright's job, it should not be beyond the capability of a resourceful and experienced seaman; but a permanent repair is essentially a task for a shipwright.

Where possible, a boat should be beached or hoisted inboard for repairs, but if the gunwales, sternpost, stem or keel have been damaged the boat should be surveyed by a shipwright before she is hoisted, because it is on these main members of her hull structure that the slinging of the boat depends.

To make an emergency repair

Cut a patch of two thicknesses of canvas, or a piece of cork linoleum, big enough to cover the hole or the area of damage with a 3-in. overlap all round; three-ply wood may also be used, but it is not as flexible as canvas or linoleum and so will not follow the contour of the hull so closely. Well coat the inner side of the patch with tallow, place it on the outside of the hull so as to cover the damage, and tack down its edges, starting from the centre of each edge and working outwards while stretching the patch as much as possible. The tacks should be about ¾ in. from the edge and about ½ in. apart. If the tacks penetrate the inner side of the planking their points should be hammered over with a light hammer in the direction of the grain of the wood while holding a heavy hammer over the head of the tack as support. This method of fastening can also be used with copper nails instead of tacks as a rough alternative to clenching where the fastenings have been damaged or have sprung. If available, a good thick coat of paint should then be applied over the patch, and over the points of the tacks on the inside of the hull.

If time and materials are available a copper tingle should be fitted over the patch, as described below.

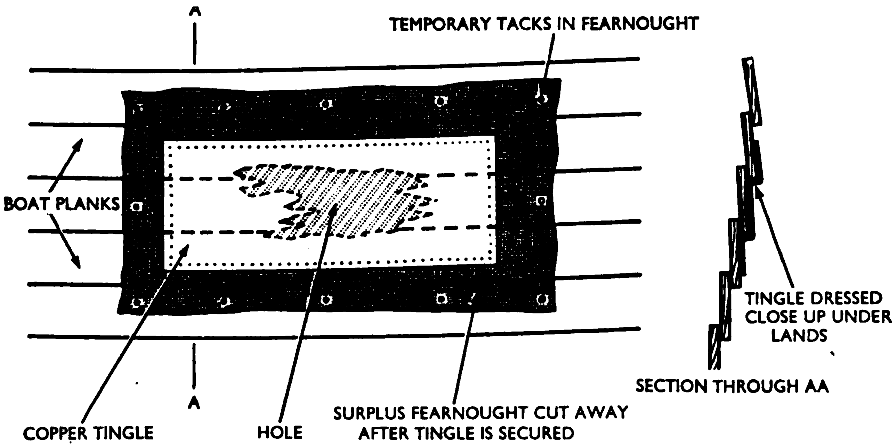


FIG. 8–26. Temporary repair with a tingle

To make a temporary repair of a small hole

A small hole or split plank should be repaired by fitting a copper tingle over it. First dress back any protruding ragged ends and fastenings, then measure the size of patch required and prepare a piece of fearnought large enough to overlap the damage by about 4 inches all round; well coat one side of the fearnought with a mixture of equal parts of tallow and white lead, stretch it over the damage and secure its edges temporarily with a few copper tacks (fig. 8–26). Now cut a sheet of thin (12-oz) copper so that it will lap the damage by 3 in. all round, and with a fine bradawl or wire nail punch small holes round the edges, about ½ in. apart and ¼ in. from the edges, to receive the tacks for securing it. Then hang the tingle in position by tacking it at the centre of its top edge, dress out any puckers in the copper by means of a beechwood wedge, and complete the tacking of the top edge by working from the centre outwards. In clinker-built boats very careful dressing is needed to fit the tingle tight up under the lands of the planking before tacking it in place. Superfluous fearnought outside the tingle should then be cut away, the heads of the tacks be smeared with a tallow and white lead mixture, and the edges of the copper tingle be dressed close home to the hull with a light hammer. Then finish it by wiping off superfluous stopping and applying a thick coat of paint.

For extensive damage—a hole 9 inches in diameter or larger, for example—some form of doubling, and perhaps stiffening, to take the place of the missing sections of planking and timbers will be required for supporting the tingle. The simplest method of fitting this support is described below and illustrated in fig. 8–27. First mark around the hole the centre lines of the timbers which will be required to take the fastenings of the doubling pieces, and then tack on the copper tingle as before. Then prepare a number of doubling pieces, from soft wood which is free of knots and about 3 in. wide by ⅝ in. thick and long enough to lap the damage by at least two timber spaces, thus enabling the doublers to be secured to the timbers. For clinker-built boats the width of these doublers will have to be the same as the width of the planks less the land.

Assuming that the patch is for a carvel-built boat, hold the first doubler flush

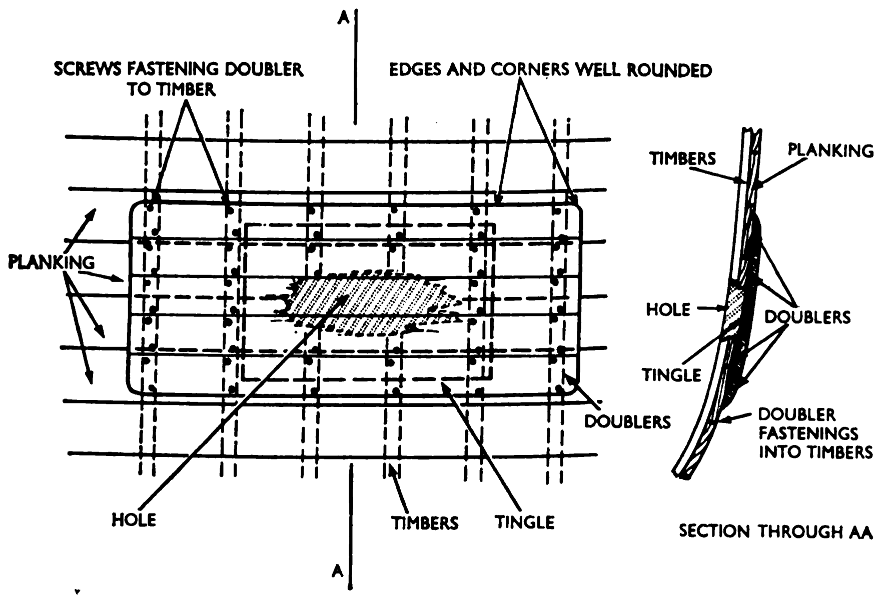


FIG. 8–27. Temporary repair with a tingle and doublers

with the top edge of the tingle, mark the lines of the timbers on it, and then bore two holes on these lines and countersink them to take fine gauge screws for securing them to the timbers; next, bore corresponding holes into but not through the timbers, and, having first coated the lower edges of the doubler with white lead, screw it in place. Try the next doubler in place, planing its edge as necessary to ensure a reasonable fit, and secure it as before; then continue fitting doublers until the whole of the copper patch is covered.

Finally, well round-off the edges and corners of the doubled patch to prevent its fouling any obstruction when the boat is alongside, plane off any inequalities in its thickness, see that all seams and edges are well stopped with white lead, and apply two coats of thick paint.

To make a semi-permanent repair of a large hole

For a large hole some form of stiffening must be introduced inside the boat, to provide a backing to which to fasten the doublers and to reinforce the planking around the hole.

First trim off any ragged ends of planking, timbers, and protruding fastenings inside the boat, so that the stiffening can be fitted closely to the edges of the hole, and then fit the copper tingle as before. Prepare the stiffener from a piece, or pieces, of three-ply so that it is the right length to fit snugly between the timbers, and wide enough to cover the hole with an overlap of about 6 in. on sound hull planking above and below the damage. The stiffener can easily be bent to the shape of the hull with a light shore about 1½ in. square, set up from some portion of the boat's structure.

Now bore holes in the stiffener, the planking, the copper tingle and the doublers, as required to take the screws for securing the stiffener into sound

hull planking above and below the hole and into the doublers, but taking care not to drill right through the planking where it is not backed by doublers, or through the doublers, and taking care to use screws which are not long enough to penetrate through them. Repeat this in as many frame spaces as necessary, and it will be found that an efficiently fitted patch of this nature will last until a permanent repair can be undertaken by the repair ship or dockyard.

BUOYANCY

All open boats have a reserve of buoyancy of at least 10 per cent; that is, when fully equipped (less loose buoyant equipment, such as oars, which would float free) and when swamped, the addition of a weight equivalent to at least 10 per cent of the weight of the boat is required in order completely to submerge the boat. The exceptions to this rule are cable-cutters, diving boats and certain survey boats in which the equipment is too heavy to be compensated by adequate buoyancy material. Boats with decks and bulkheads are fitted with buoyance material in proportion to their likelihood of being swamped.

Pulling and sailing boats are swamp-tested every two years. The tests are normally carried out by the dockyard, but should a ship suspect that the buoyancy of a boat is less than adequate, a test can be carried out as follows.

Testing a boat's buoyancy

A ship cannot conveniently weigh a boat, so the weight given in the table on page 293 must be used.

The boat is lowered to the water, her falls are left hooked on but slack, and the plug is withdrawn. When the level of water is the same inside and outside the boat, ballast is lowered and distributed evenly until the boat is in a sinking condition. Should the weight of ballast be less than one-tenth of the boat's total weight, extra buoyancy must be provided by lashing drums or casks beneath the thwarts until the boat can be tested in a dockyard and permanent buoyancy blocks fitted.

EXAMPLE

Weight of boat and equipment	26 cwt	
Required positive buoyancy	2·6 cwt	= 291 lb
Weight of immersed iron ballast used to swamp		= 195 lb
Weight of ballast 'in water'	$\frac{13}{15} \times 195$	= 169 lb
Extra buoyancy to be provided	$291 - 169$	= 122 lb

The volume in cubic feet of this extra buoyancy can be found by dividing the weight by 64 (1 cu. ft of sea water weighs approx. 64 lb). Therefore about 2 cu. ft of cask or drum must be lashed beneath the thwarts. The dimensions of a cask or drum to provide this buoyancy may be calculated from the formula given in Appendix I (page 606).

Testing power boats

Swamp-testing of power boats (and this includes the motor whaler) cannot be carried out by ship's staff. All machinery and electrical items have to be removed from the boat and an equivalent weight substituted for the test.

CHAPTER 9

Anchors and Cables, and Anchor Work

Every ship anchors countless times during her life. Unless her anchors, cables and associated gear are efficient and able to withstand the strains imposed by foul weather and strong tidal streams, her crew will suffer from lack of rest and her engines and boilers (if fitted) will be overworked.

In Volume I the seaman was told how an anchor holds in the sea-bed; he was also introduced to some of the gear, a modern anchor, cable, arrangements of anchors and cables, and the sequence of events leading up to, and including, bringing a ship to a single anchor and to a buoy. This chapter includes a description of all of the gear and how it is worked, tested and looked after, and a guide to the seaman in selecting the amount of cable to veer when anchoring. Volume III includes shiphandling, selection of berth and the special navigational aspects of this subject with which an officer may be faced, also permanent moorings.

Formulae for calculating breaking strengths, etc. will be found in Appendix I (page 599).

ANCHORS AND CABLES

TYPES OF ANCHOR

The bigger the ship the heavier must be her anchors. Anchors also vary in design and performance as well as in size. Details of the anchors carried by ships of the Fleet are given in the table on page 310, while the most common types are illustrated in fig. 9–1.

Admiralty pattern anchor

In spite of its name, this anchor is much older than the Admiralty itself and for long was considered by seamen to afford the greatest holding pull, i.e. 3 to 3½ times its own weight; but some of the modern anchors are very much superior in this respect. It is still used for some boats' anchors. When the anchor is let go the stock comes to rest horizontally on the bottom, and as the flukes are set at right-angles to the stock the lower fluke digs into the bottom and holds. Its disadvantage is that, because the upper fluke sticks up from the bottom, the anchor may well be dislodged through being fouled by the bight of its cable as the boat swings to wind and tidal stream; it is also dangerous if let go in shallow water, because a boat may impale herself on the upper fluke when the tide falls. It cannot be stowed in a hawsepipe, and so it must be stowed on deck or slung in some position from which it can be let go. A large anchor of this type is awkward to handle and wasteful of material, because the upper fluke cannot contribute to the holding pull.

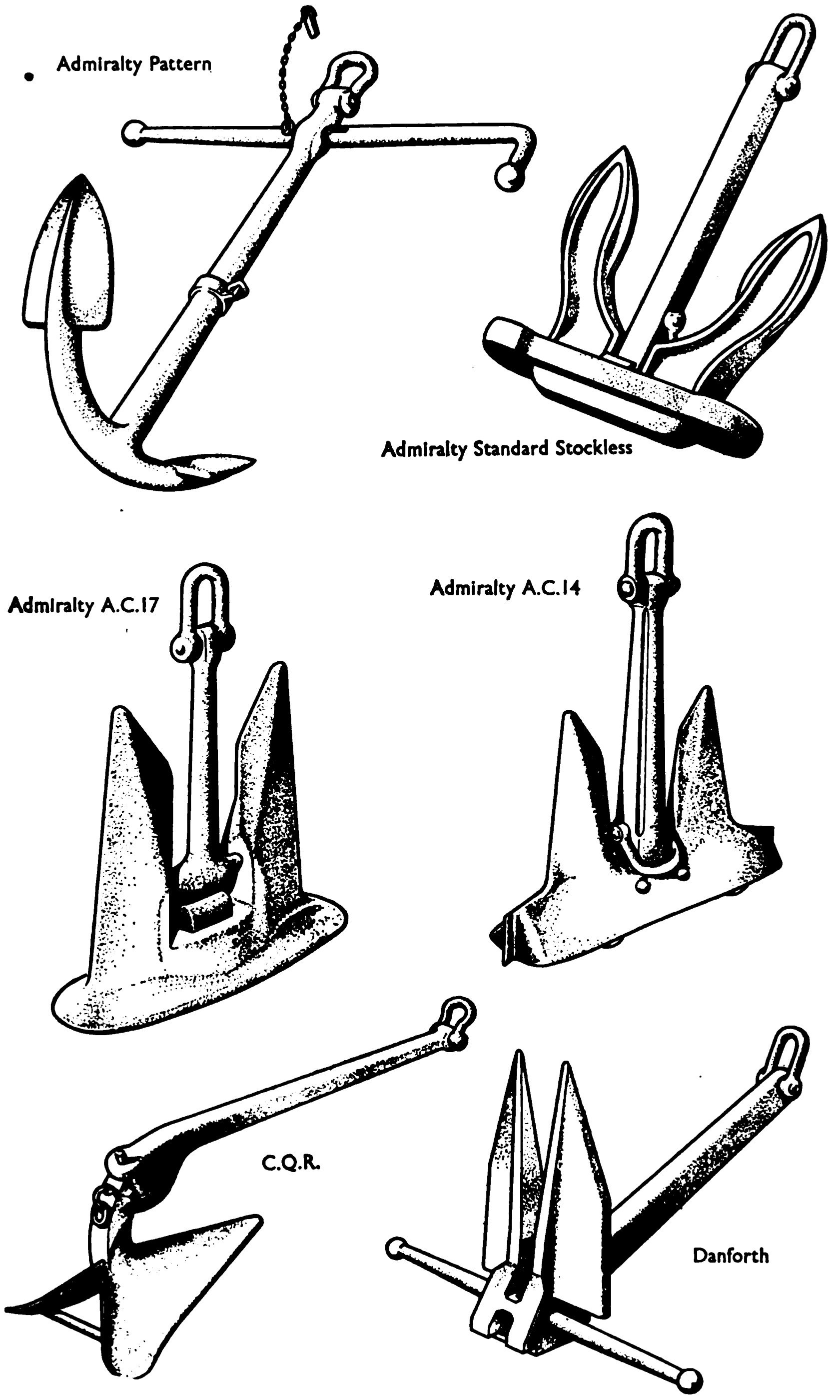


FIG. 9–1. Types of anchor

Admiralty standard stockless anchor

As its name implies, this anchor has no stock and can therefore be hove right home in the hawsepipe, where it is easily secured and quickly made ready for letting go. The maximum holding pull is about the same as that of the Admiralty pattern, i.e. 3–3½ times its own weight, and it is used for the bower anchors of cruisers and larger ships, also some frigates and destroyers and also for stream (stern) anchors when fitted. The flukes pivot about a pin which passes through the crown. As the anchor is dragged along the bottom the weight of the flukes and the effect of the tripping palm tilt both flukes downward so that they dig into the bottom. The angle through which the flukes can tilt is limited by stops forged in the crown.

Several types of stockless anchor may be found in the Royal Navy and in the Merchant Navy. The most common are the Admiralty Standard, Byer's, Taylor's, Martin's and Hall's; their general design is similar and they vary only in detail.

Admiralty type A.C.14 anchor

In 1943 the Admiralty instituted a series of tests aimed at improving the ratio between the holding pull and anchor weight. These tests resulted in a major advance in anchor design and the A.C.12, and later the A.C.14, anchor were adopted for new ships of the Fleet. The holding pull of the A.C.14 is three times that of the Admiralty Standard stockless anchor, and the ratio between holding pull and anchor weight is approximately 10 : 1. In addition it is designed so that it will quickly bite and will achieve maximum holding pull after dragging two shank-lengths.

When the force on the ship due to wind and tide reaches such a value that the anchor drags, the A.C.12 and A.C.14 anchors have a tendency to roll to one side or the other by only an insignificant amount compared with that of the A.S.S. type anchors.

The holding pull of all anchors is greatly reduced if the cable is not pulled horizontally at the anchor shackle. This problem is discussed on page 335.

Admiralty types A.C.16A and A.C.17 anchors

The stowage of an anchor in a submarine has always been difficult, and with the introduction of high-speed heavy nuclear-powered vessels the requirement for an anchor which, when stowed, is flush with the hull and completely closes the hull opening has become of vital importance. A further requirement is for the anchor to be worked blind, by remote control.

The *A.C.16A* anchor was designed for stowage in the bottom of the hull where for various reasons the hawsepipe could not be arranged sufficiently close to the vertical. To ensure correct entry of the anchor into its stowage, the shank on entering the hawsepipe tilts normal to the hull and then rotates to line up the flukes with the hull opening. The rotation is effected by means of a guide pin in the upper end of the shank and a cam within the hawsepipe. The anchor will enter with the flukes tumbled either way and the crown completely closes the opening. The remote controls include indicators which allow the position of the anchor to be checked during the securing evolution. The ratio of holding

pull to anchor weight is approximately 2·6 : 1 in mud, and 3·6 : 1 in sand, shingle and clay.

The *A.C.17* anchor, also designed for stowage in the bottom of the hull, has a holding pull of about 7 times its own weight, but requires to be stowed with its shank vertical, or near vertical, and normal to the hull opening. The flukes are balanced so that they lie in line with the shank and can thus enter a comparatively narrow opening in the hull if the anchor is rotated to the correct position (normally fore and aft) prior to entry. Rotation is effected by a ball and pin inserted between the cable and the anchor shackle; the pin connects with a guide cam within the hawsepipe. The crown of the anchor when stowed lies flush with the hull and completely closes the hull opening. Remote control and warning devices are fitted as for the A.C.16A anchor.

Danforth anchor

This anchor is of comparatively new design, giving a better holding pull for a given weight than the older small-ship anchors. The holding pull to weight ratio increases as the size decreases. It can therefore be used as a bower anchor in small vessels such as coastal and inshore minesweepers, and as a killick or general-purpose anchor in conventional destroyers and similar ships. It resembles a lightly-built stockless anchor, both in appearance and method of operating, but it has a small stock passing through the crown to prevent the anchor from rolling when its flukes dig into the bottom. It fits snugly into the hawsepipe and can be secured as efficiently as a stockless anchor, but, as with all other anchors, it loses holding pull considerably when at short stay.

C.Q.R. anchor

This anchor also has a better holding pull than the older type of anchor and the holding pull to weight ratio increases as the size decreases. It has a bent shank with a plough-shaped fitting hinged to the end. It is generally used only for small craft, because it is difficult to stow in a hawsepipe. The sharp point of the fluke increases the risk of damage to the hull plating when weighing.

CHAIN CABLE

The bower cables of men-of-war are made of studded chain, because chain can withstand the wear and tear imposed on a ship's cable and the studs in the link strengthen them and prevent the cable from kinking. Studded chain cable is made in lengths of 15 and 7½ fathoms called 'shackles' and 'half-shackles' of cable respectively. A ship's bower cable is usually made up of four half-shackles of cable and a number of shackles of cable. The half-shackles are usually inserted in pairs, one at the outboard end next to the anchor, and the other midway between the outboard and inboard ends. The reason for this spacing will become apparent in the Anchor Work section (page 342).

Types of chain cable

There are many different types of ship's cable. Those used in Navy Department service are:

Admiralty-quality forged steel
Admiralty-quality wrought iron
Admiralty-quality non-ferrous, manufactured from aluminium bronze material
Merchant-quality forged steel
Merchant-quality mild steel
Merchant-quality wrought iron.

Most men-of-war are now supplied with Admiralty-quality forged steel cable (except minesweepers, which require non-magnetic cable). It is 40 per cent stronger than wrought iron cable and can therefore be smaller and lighter for the same breaking strength. Admiralty-quality wrought iron cable is usually fitted only in non-operational vessels, some Depot ships and some submarines; its strength is the same as Merchant-quality wrought iron cable, but it is of superior finish. Mild steel cable is not fitted in British-built ships. Merchant-quality cable is fitted in some Royal Fleet Auxiliaries and similar craft.

Particulars of the cables supplied to ships of the Fleet are given in the table on page 310. The size of cable quoted in this table and always used in practice is the diameter of the element of metal forming the common link (for definition of 'common link' see below). The size always quoted for an anchor shackle, joining shackle or other cable gear is that of the cable with which the gear is intended to be used.

Components of a shackle of chain cable

The links forming each length of cable are of uniform size and are called *common links*, but those at each end of each length, which are required to take lugged shackles, are stepped up in size to take the joining or anchor shackles.

Forged steel cable with lugless joining shackles (fig. 9–2(i)). The common links of forged steel cable fit round one another more loosely than do those of wrought iron cable and can therefore take a lugless joining shackle without having an enlarged link included at each end.

Wrought iron cable with lugless joining shackles (fig. 9–2(ii)). As the lugless joining shackle is just too large to fit on the common link, a slightly enlarged studded link is fitted at each end of each length of cable. This enlarged link is called an *F link* and is slightly smaller than the 'intermediate link' described below. The illustration shows one end of a length of wrought-iron cable fitted with lugless joining shackles. Lugless anchor shackles for this cable are designed to fit an unstudded 'end link', which is described below.

Cable with lugged joining shackles (fig. 9–2(iii)). As the lugs of a joining shackle are too big to pass through any studded link, an unstudded link has to be provided to take them. This is called the *end link*, and being unstudded it has to be made thicker than the common link in order to be as strong. A slightly enlarged studded link, called an *intermediate link*, is inserted to connect the end link to the first common link. The illustration shows the positions of these links at one end of a length of this cable. The lugged anchor shackles for this cable are, of course, also designed for shackling on to an end link.

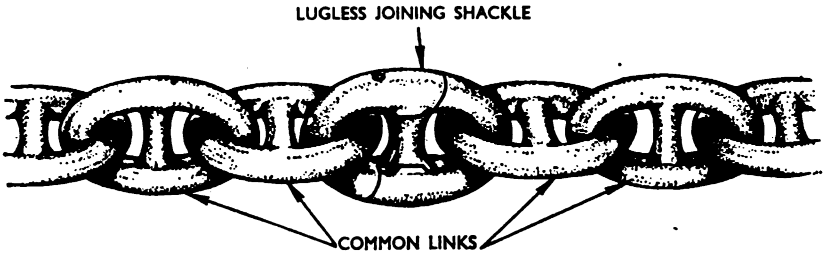
ANCHORS AND CABLES SUPPLIED TO H.M. SHIPS

Class of Ship	Displacement	Bower Anchors	Type	Killicks	Size of Cable	No. of Shackles	No. of Half-shackles	Total Length
	tons	cwt		lb	in.			fm
Carriers								
Ark Royal	53,000	two of 190	B	—	3 F.S.	29	11	517½
Centaur	27,000	two of 160	B	—	2¾ F.S.	22	11	412½
Depot ship								
Forth	11,000	two of 120	B	—	2½ W.I.	22	8	390
Cruisers								
Tiger class	12,000	two of 95	A.S.S.	—	2 F.S.	20	10	375
Destroyers								
County class	5,500	two of 52	A.C.14		1⅞ F.S.	14	8	270
Daring class	3,600	two of 45	A.S.S.	one of 300 D	1½ F.S.	10	8	210
CA class	2,600	two of 34	A.S.S.	one of 300 D	1 5/16 F.S.	10	8	210
Frigates								
Tribal class	2,300	two of 32	A.C.14	one of 300 D	1⅜ F.S.	10	8	210
Whitby class	2,800	two of 28	A.C.12*M*	one of 300 D	1 5/16 F.S.	10	8	210
Leopard class ..	2,400	two of 34	A.S.S.	one of 300 D	1 5/16 F.S.	10	8	210
Blackwood class ..	1,500	two of 19	A.C.12*M*	one of 300 D	1⅛ F.S.	10	8	210
Submarines								
Porpoise class ..	1,700	one of 16	B	—	1 W.I.	5	—	75
'A' class	1,400	one of 12	M	—	⅞ W.I.	5	—	75

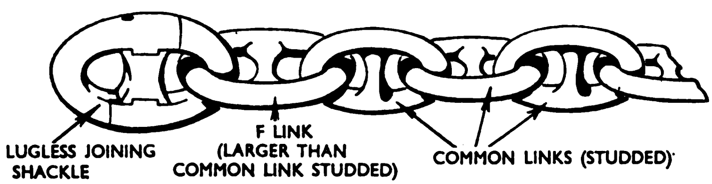
A.C. — Admiralty Cast
A.S.S. — Admiralty Standard Stockless
B — Byer's

D — Danforth
M — Martin's
M — Modified

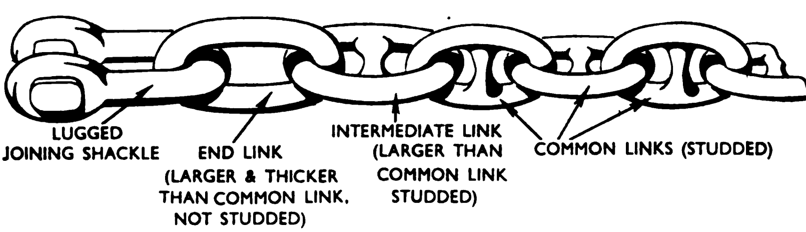
F.S. — Forged Steel
W.I. — Wrought Iron



(i) Forged steel cable with lugless joining shackle



(ii) Wrought iron cable with lugless joining shackle



(iii) Cable with lugged joining shackle

FIG. 9–2. Components of a shackle of chain cable

Marking of cable

The shackles and joining shackles of a cable are numbered consecutively from its outer to its inner end, the first joining shackle being that which joins the first and second shackles together. To assist the Cable Officer in identifying the joining shackles when cable is being worked, the cable is marked as follows (fig. 9–3).

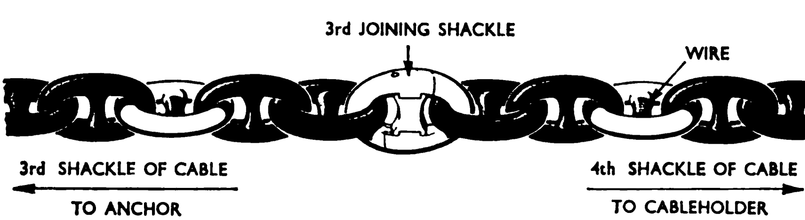


FIG. 9–3. Marking of cable

Every joining shackle is painted white. Except at the joining shackles between two half-shackles a link on each side of the joining shackle is painted white; for example, the illustration shows that the third joining shackle is on deck, because the third link on each side of the joining shackle is painted white. In addition, the stud of the painted link has turns of seizing wire round it.

Cable lockers

The cable lockers—which may be sited so that one is abreast, or forward, of the other and usually on the lowest deck—provide the stowage for the cables. Their sides are usually of steel plating, perforated to ventilate and drain the cable. The inboard end of the cable is shackled to a cable clench at the bottom of the locker. The clench is tested to 20 per cent above the proof load of the cable. The cable locker may be self-stowing, so that the descending cable will automatically stow itself clear for running out. If it is not self-stowing an eye-plate is fitted to the deck-head above each corner of the locker; cordage strands are attached to these eyeplates and are hitched and then unhitched successively to the cable as it comes in so as to guide it into each corner of the locker. The cable of a small ship is easily stowed by hand.

ASSOCIATED GEAR

This consists of all the portable items used in conjunction with anchors and cables, rather than the associated fittings (described later) which are part of the ship's permanent structure.

Joining shackles

The shackles which join the lengths of cable to each other may be either lugless or lugged; all men-of-war are fitted with the lugless type, and many auxiliary vessels have the lugged type.

The *lugless joining shackle* (fig. 9–4(i)) is of alloy steel and made in three parts, one of which is the stud. The two main parts are attached to the ends of the cable and then fitted together, and the stud then slides in place and locks the whole. The stud is secured by hammering a tapered pin and lead pellet into the hole drilled diagonally through all three parts of the shackle. This hole is tapered, and when the pin is driven right home a small conical recess, called the *dovetail chamber*, is left clear above its head. The lead pellet is hammered broad end first into this chamber so as to fill it completely and thereby keep the pin in place. During the final stage of hammering there is some danger to the eyes from small, flat pieces of lead flying off the shackle unless the blows are softened.

Before inserting a pellet the remains of the former one must be scraped out of the chamber, otherwise the new pellet may work out; this is done with a small tool called a *reamer*. When parting a lugless joining shackle a *top swage* (fig. 9–4(i)) must always be used between the hammer and shackle. It is shaped to the curvature of the shackle so that the machined surfaces of the shackle shall not be damaged.

The *lugged joining shackle* (fig. 9–4(ii)) is a straight shackle whose bolt is

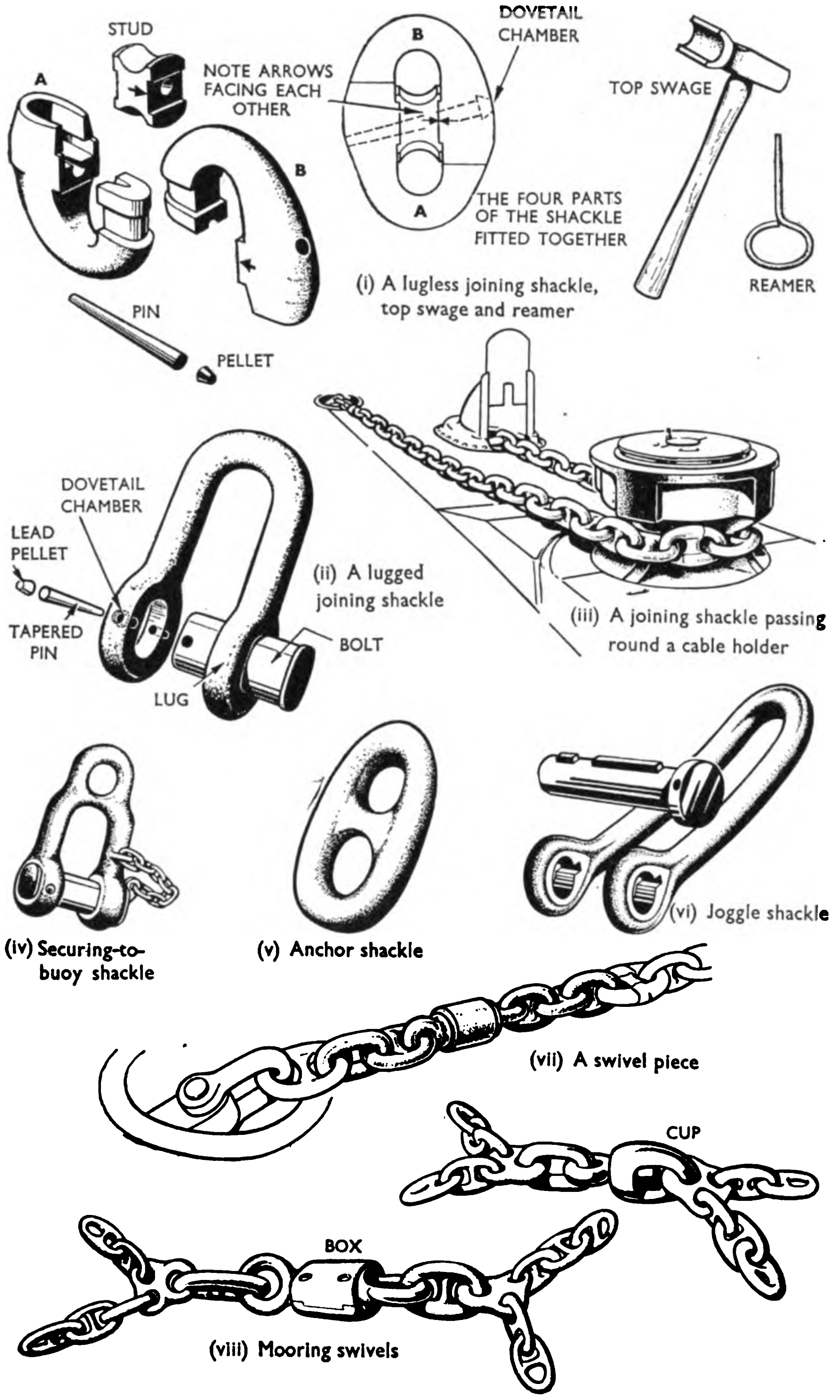


FIG. 9-4. Associated gear (1)

secured by a tapered pin and lead pellet. The pin fits into a tapered hole drilled through the bolt and one lug of the shackle; the treatment of the pellet is the same as for a lugless shackle. Except for the anchor shackle all lugged shackles should be fitted into the cable with their lugs facing aft, so that they will not foul any projections on the deck as the cable runs out. Since the anchor shackle is already in the hawspipe, there is no danger of fouling anything on the way out, but it may foul the stem or some projection on the ship's side while the anchor is being hove in, so it should be fitted with its lugs facing outboard.

NOTE.—Joining shackles, being slightly larger than the links, will jam or be strained if they are made to pass round the sprocket of a cable holder, or the gypsy of a windlass, while on the wrong slew. Both types of shackle should lie *vertically* (fig. 9–4(iii)) as they pass round a cable holder or horizontally when they pass over the gypsy of a windlass. To ensure that all joining shackles pass round a cable holder or windlass on the same slew, a shackle of cable is always made up of an odd number of links.

Securing-to-buoy shackle

This shackle (fig. 9–4(iv)) is supplied for joining the ship's bridle to the buoy shackle or reducing link of a mooring buoy, and is therefore especially wide in the clear. It can be used with either lugless or lugged joining shackles, and is tested to the proof load of its associated cable. The width of the shackle in the clear for cable of all sizes is given in the following table:

Size of cable (*in.*)	*Width of shackle in the clear* (*in.*)
$1\frac{1}{8}$ and below	$3\frac{3}{4}$
from above $1\frac{1}{8}$ to $1\frac{1}{2}$	$4\frac{1}{2}$
from above $1\frac{1}{2}$ to $1\frac{7}{8}$	$5\frac{3}{4}$
from above $1\frac{7}{8}$ to $2\frac{1}{4}$	$7\frac{1}{4}$
above $2\frac{1}{4}$	$8\frac{1}{4}$

Anchor shackle

An anchor shackle, which can be either lugless or lugged, is used to join the swivel piece at the outboard end of the cable to the ring of the anchor. Fig. 9–4(v) shows a lugless type which is slightly pear-shaped. The larger diameter is connected to the ring of the anchor and the smaller to the swivel, because the size of the ring is greater than that of the link of the swivel. When any lugless shackle is being broken a top swage must be used.

Joggle shackle

This is a long and slightly curved shackle (fig. 9–4(vi)), shaped to fit across a link of cable; it is used for attaching a wire rope to a bight of cable (see page 342). The bolt fits easily in the lugs and is held in place by feathers protruding from it; to remove or insert the bolt it must first be turned until the feathers are in line with the featherways cut in the lugs of the shackle. The table on the next page gives the proof loads of the joggle shackles supplied for different sizes of cable.

Size of cable (*in.*)	*Diameter of bolt* (*in.*)	*Proof load* (*tons*)
$\frac{3}{4}$ to below $1\frac{1}{8}$	$1\frac{1}{4}$	10
$1\frac{1}{8}$ to $1\frac{7}{16}$	$1\frac{5}{8}$	15
$1\frac{1}{2}$ to 2	$1\frac{7}{8}$	25
$2\frac{1}{8}$ to $2\frac{3}{8}$	$2\frac{5}{16}$	30
$2\frac{1}{2}$ and above	$2\frac{3}{8}$	40

Adaptor piece

This consists of an intermediate link and end link joined together and is allowed to ships having cables joined with lugless shackles. It is shackled to the inboard end of the swivel piece so that the end link will take the lugged shackle by which the end of the *ganger* is secured when laying out a bower anchor (Chapter 10). It is also used when forged steel cable is shackled to a wire towing hawser.

Swivel pieces

The swivel pieces which are fitted at each end of the complete cable each consist of a swivel with a few links each side of it, and they differ in detail with the type of joining shackle used. Fig. 9–4(vii) shows the arrangement of an outboard box swivel for use with forged steel cable with a lugless joining shackle and a lugless anchor shackle. The inboard swivel is always secured to the cable clench with a lugged joining shackle. The cup swivel, designed for wrought iron cable, should always be inserted in the cable with its cup facing aft.

Mooring swivel

This is used to prevent turns forming in the cables when a ship is moored between her two anchors. It consists of a swivel with a three-eyed plate (*monkey face* or *shamrock plate*) at each end, one eye of each plate being attached to the swivel, either directly or by means of a special enlarged link, and the remaining two being linked to short legs of cable (fig. 9–4(viii)). The composition of these legs depends on whether the cable has lugless or lugged joining shackles; for lugless shackles one leg on each side of the swivel consists of two common links (for forged steel cable) and the other leg on each side of three common links; for lugged shackles one leg consists of a single unstudded link and the other of two unstudded links. There are two types of mooring swivel; the box swivel for forged steel cable, and the cup swivel for wrought iron cable. The purpose of having one leg on each side of the swivel fitted with an odd number of links and the other an even number is explained on page 342.

Stoppers

Cable stoppers (fig. 9–5), usually known as *slips*, are provided to act as preventers when the ship is riding on the brake of the cable holder, or to hold the cable temporarily so that the inboard part of it can be handled, or to house the anchor securely in the hawsepipe.

A *Blake slip* is a general-purpose slip which can be used either as a preventer or to hang the cable whilst working on its inboard part, or for securing the soft

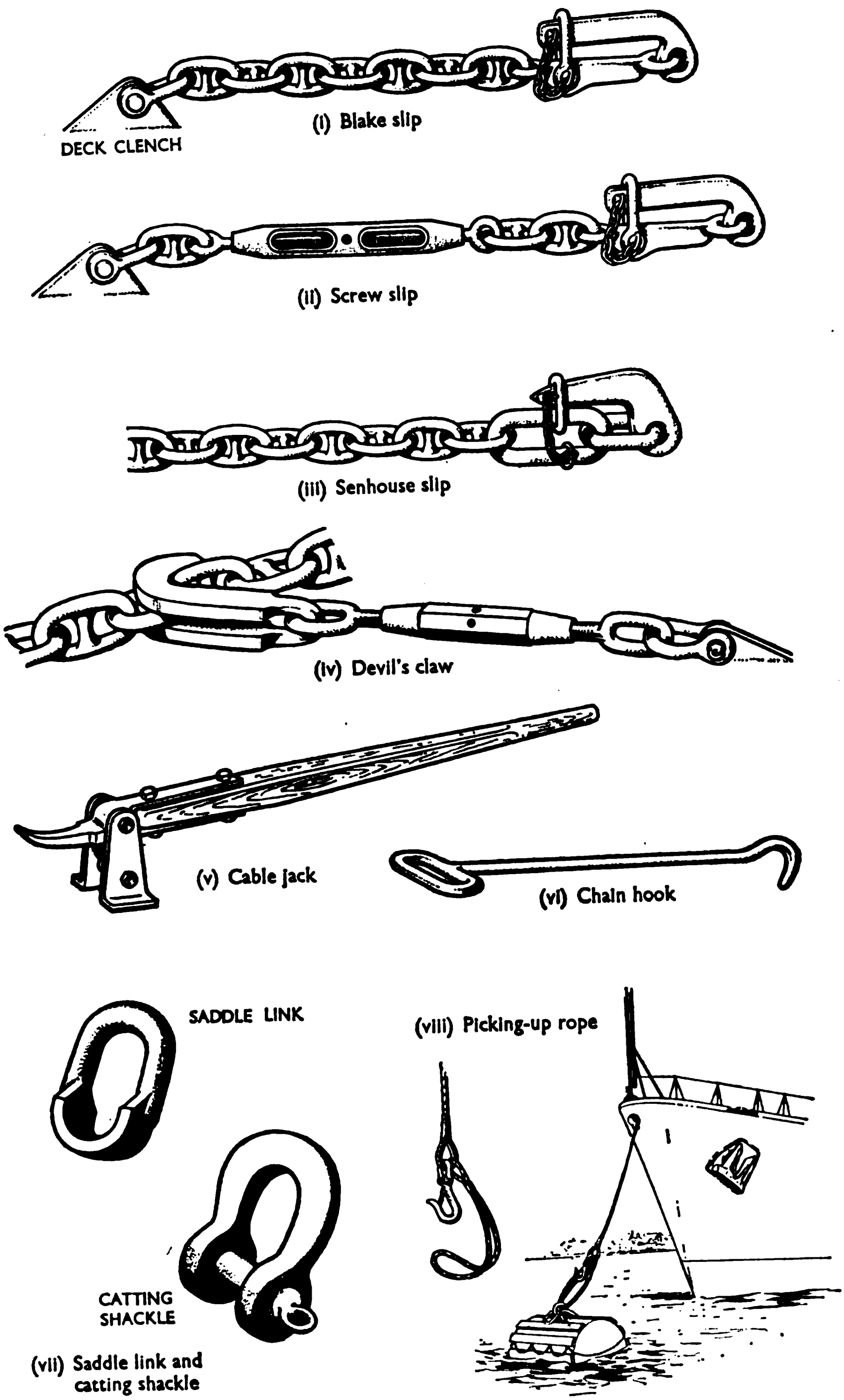


FIG. 9–5. Associated gear (2)

eye of a wire which may require quick release. It is tested to half the proof load of the cable.

A *screw slip* differs from the Blake slip only in that a bottlescrew is incorporated in the chain between the slip and the deck clench. The bottlescrew enables the anchor to be hove hard home in its hawsepipe when secured for sea. It is tested to half the proof load of the cable.

A *riding slip* is a Blake slip shackled to a deck clench on the deck immediately above each cable locker, or on the upper deck between the navel pipe and cable holder. It is put on the riding cable when the ship is at anchor, or on the working bridle when secured to a buoy, or on both cables when the ship is moored. The ship rides by the brake of the cable holder, and the riding slip acts as a preventer should the brake render. The slip is tested to half the proof load of the cable.

NOTE.—The deck clenches (or *lug plates*) to which these slips are shackled are tested to 20 per cent more than the slips.

A *Senhouse slip* is designed to hold the end of a length of cable. The tongue is passed *through* a studless link and not *across* a link, as in the case of the Blake and screw slips. It is used also in the *catting sling* of an anchor, the purpose of which is described later.

Devil's claw. In many merchant ships the cable is stoppered by a devil's claw, as illustrated in fig. 9–5(iv).

Cable jack

This is a handspike mounted on a pedestal which functions as a fulcrum (fig. 9–5(v)). It is used as a lever to lift up heavy cable so that, for example, the tongue of a slip can be passed under it.

Chain hook

This is an iron hook with a long handle (fig. 9–5(vi)) used for hauling *detached* lengths of chain cable when ranging it, e.g. for survey. Chain hooks should *never* be used on the forecastle or in the cable locker when the cable is being worked by power, as they are liable to jam in the cable; a cordage strand is equally effective and much safer.

Parting strop

This is used to separate parts of cable which are lying close together, so that, for example, the tongue of a slip may be passed between them. The strop is passed through a link of one cable, beyond the stud, and both bights secured to a convenient eyeplate. By veering the cable slowly part of its weight is transferred to the strop, and the cables can then be separated.

Hook rope

This is a wire or cordage rope with a hook fitted to its end, and is much used for manhandling cable.

Bullrope

This is a rope used for ranging cable, lighting cable through a stem hawsepipe or bullring, and for adjusting the height and position of the end of a ship's

bridle to enable it to be shackled to the buoy shackle, or to one of the reducing links, of a mooring buoy. It is used on a capstan or warping drum, or it is tailed with a tackle.

Catting pendant

This is a wire pendant fitted at one end with a *saddle link* (fig. 9–5(vii)) which distributes the weight of the anchor over the long bolt of the *catting shackle*, and is used when the anchor is required to be catted (see page 347). The catting shackle takes the ring of the anchor, and for this reason is made very wide in the clear.

Picking-up rope

This wire rope (fig. 9–5(viii)) has a spring hook and long grommet strop at one end to haul the ship close up to a mooring buoy so that her bridle may be shackled on; and a soft eye at the other end so that it can be used as a *sliprope* to take the weight off the bridle when unshackling. The sliprope is rove through the buoy shackle and the soft eye placed on a slip. The table below gives details of the picking-up ropes for ships of various tonnages.

DETAILS OF PICKING-UP ROPES FOR SHIPS

Tonnage of ship	Size and type of wire rope	Size and type of strop
Up to 2,000	2½-in. F.S.W.R.	1½-in. F.S.W.R.
2,000 to 3,000.. ..	3-in. F.S.W.R.	2-in. F.S.W.R.
3,000 to 5,000.. ..	3½-in. F.S.W.R.	2½-in. F.S.W.R.
5,000 to 10,000 ..	4-in. F.S.W.R.	2½-in. F.S.W.R.
Over 10,000	4-in. E.S.F.S.W.R.	3-in. E.S.F.S.W.R.

Anchor strop

This is used as an additional preventer when securing the anchor for sea; it consists of a wire strop rove through the ring of the anchor and shackled to an eyeplate on each side of, and just abaft, the hawsepipe.

Anchor buoy

This buoy is used to mark the position of the anchor when it is on the bottom, and is always streamed before the anchor is let go. Its use is of particular importance in crowded anchorages to enable other vessels to keep clear of your anchors and cables. The anchor buoy used in the Royal Navy consists of a strengthened barricoe, fitted with slings to which the buoy-rope is bent. To avoid damage by chafing on the bottom the buoy-rope is attached to the anchor by a short length of rigging chain shackled to the gravity band or crown of the anchor.

The length of the buoy-rope must be adjusted so that the buoy will continue

to *watch* at high water. (A buoy is said to 'watch' when it floats, and is not watching when carried under the surface by the stream or the rise of the tide.) Buoys should be painted red for the port anchor and green for the starboard anchor.

ASSOCIATED FITTINGS

These fittings are used in conjunction with anchors and cables and their associated gear. Cable holders, capstans and windlasses are described on page 321.

Hawsepipes

A hawsepipe is a steel tube which houses the anchor in its stowed position or gives a lead for the cable during anchor work. The diameter of a hawsepipe should be not less than twelve times the diameter of the chain cable. Most ships are fitted with port and starboard hawsepipes to house their bower anchors, but some are fitted with a third hawsepipe in the stem called a 'stem hawsepipe' (illustrated in Volume I) for giving a fair lead to the cable when the ship is secured to a buoy, or when being towed. At the lower end of a bower anchor hawsepipe, if the ship-side plating is not flush with the lip of the hawsepipe, an *arris piece* is fitted to prevent the anchor flukes from jamming under the protruding lip. An arris piece is a wedge-shaped piece of steel which, when fitted to two surfaces having a different level, gives a uniform, uninterrupted slope from one level to the other.

The hawsepipe of a modern submarine has already been described (page 307)

Navel pipes

These pipes are fitted forward of the cable holders, or incorporated in the base of a windlass, for the passage of the anchor cables to and from the cable lockers. Their upper ends stand proud of the deck to ensure smooth working of the cable and prevent wash deck water finding its way below.

Bonnets

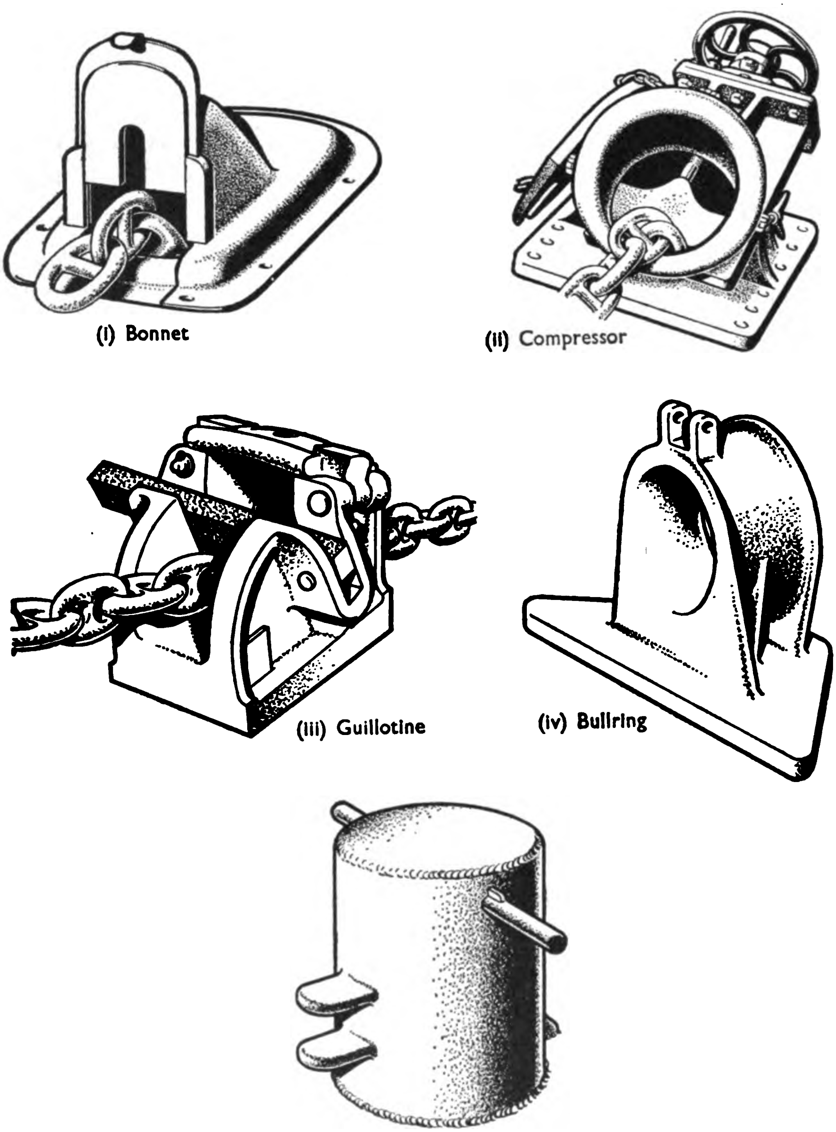
A bonnet (fig. 9–6(i)) is a fixed or portable cover for a navel pipe to stop water from flooding the cable locker. The opening, which faces aft, is made reasonably watertight by a portable steel cover, slotted to slide down over one link of the cable. Portable bonnets are sometimes replaced by flat covers when no cable runs through the pipe.

Hawsepipes are fitted with covers or bonnets to stop large quantities of water flooding the forecastle in a heavy sea.

Compressor

Some destroyers and frigates with fixed bonnets have compressors fitted in the bonnets to take the place of riding slips. A compressor (fig. 9–6(ii)) consists of a pear-shaped wedge of steel on a screwed spindle, operated by a handwheel; the wedge can be moved down across the mouth of the navel pipe until it nips a link of the cable against the lip. A portable cover fits over the mouth of the bonnet.

NOTE.—In ships fitted with a windlass the opening of the navel pipe at deck level is fitted with a canvas cover or steel plate.



(v) Bitts

FIG. 9–6. Associated fittings

Guillotine

This (fig. 9–6(iii)) is fitted in ships which have windlasses, e.g. coastal minesweepers and many merchant ships. It normally takes the place of a riding slip or compressor (see also Volume I, fig. 11–10).

Bullring

In destroyers and below a bullring (fig. 9–6(iv)) is fitted to give a fair lead to the picking-up rope or to the bullrope. In older ships the bullring was used when being towed, and was large enough to take two bridles when secured to a buoy. Most modern ships are fitted with a stem hawsepipe for such purposes.

Bitts

In some modern men-of-war a single bitt (fig. 9–6(v)) is fitted on the forecastle abaft the stem hawsepipe. It is used for securing berthing hawsers or the standing bridle when the ship is made fast with two bridles to a mooring buoy. The *battledores* are used to separate the parts of the cable round the bitt, and the *bitt pin* is to prevent the cable jumping off the bitt. Cable is *bitted* by hauling up slack cable and taking a complete turn round the bitts, the outboard end passing under the lower battledore and the inboard end between them.

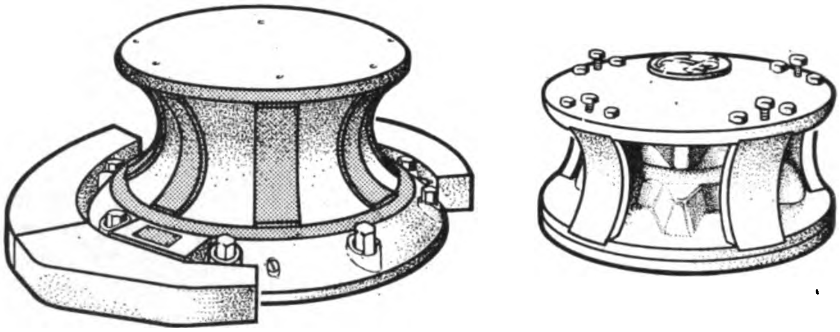
Clump cathead

When large ships without stem hawsepipes are secured to a buoy the bridles usually pass through one of the bower anchor hawsepipes. To leave enough room for the bridles in the hawsepipe the anchor must first be removed and stowed. A clump cathead, which consists of a sheave mounted on a strong fitting on each bow abaft the hawsepipe, is provided for slinging the anchor, which is then said to be *catted*. The anchor is first hove up to this sheave by the catting pendant, and then secured there by a chain sling which is fitted with a long end link to take the tongue of its special Senhouse slip. Catting an anchor is described more fully on page 347.

CAPSTANS, CABLE HOLDERS AND WINDLASSES

Capstans

A capstan in its simpler form has a *barrel* or *rundle* mounted on a vertical spindle which is driven by a steam engine, or electric or hydraulic motor, and is used for working hawsers or warps. The barrel is waisted, i.e. made smaller in diameter at its middle than at its top and bottom, with the object of checking the tendency of the turns of rope to work up or down and so form a riding turn as the capstan revolves. The same rules apply for a riding turn on a capstan as for a warping drum described on page 192. It is sufficient to add that if the turns of rope are reluctant to slip towards the middle of the barrel, slight surging of the rope will usually induce them to do so. If surging has no effect upon the turns building up towards the top of the barrel then it is likely that too many turns have been taken round the barrel. The frictional surface of a capstan is probably equal to that of a twin bollard: the seaman should therefore refresh his memory on surging from Chapters 6 and 8 of Volume I.



(i) Aft (ii) Forecastle

FIG. 9–7. (i) An after capstan; (ii) a typical forecastle capstan

Standing out at intervals from the barrel, and extending from top to bottom, are slight projections called *whelps*, which are cast with the barrel and help it to grip the rope. The capstan illustrated in fig. 9–7(i), is fitted in guided missile destroyers.

Fig. 9–7(ii) shows a typical forecastle capstan for working the hawsers and cables of cruisers and above. The barrel is formed by portable whelps, which, when removed, disclose the *sprocket* to which the cable can be brought. The projections on the sprocket are called *snugs*, and are designed to fit and grip the links of the cable so that the cable of the bower anchor can be brought to the capstan. The method of weighing anchor by centre line capstan is described on page 339.

Cable holders

A cable holder is designed solely for working cables. It consists of a sprocket with snugs and is mounted on a spindle driven through worm gearing either by the capstan engine or by its own separate engine. The sprocket can revolve freely on its shaft, or be connected to its shaft by a dog clutch situated in the head of the sprocket. When it is disconnected the rotation of the sprocket can be controlled by a band brake operated by a handwheel; when connected the sprocket will hold the cable and can be made to heave in or veer the cable by driving the engine in the required direction.

The operation of the clutch (fig. 9–8). A circular plate called a *dog plate* is keyed to the head of the spindle and revolves within the head of the sprocket. The dog plate is slotted to take two dogs which can be slid inwards or outwards along their slots. Each dog has a pin which takes in a curved slot in the *scroll plate*, which is mounted directly above the dog plate; the movement of the dogs inward or outward is therefore controlled by turning the scroll plate in the required direction. The dogs, however, are prevented from sliding outwards by the head of the sprocket unless the slots in the sprocket head coincide with the slots of the dog plate.

To connect the sprocket to its spindle the brake is put on and the spindle is

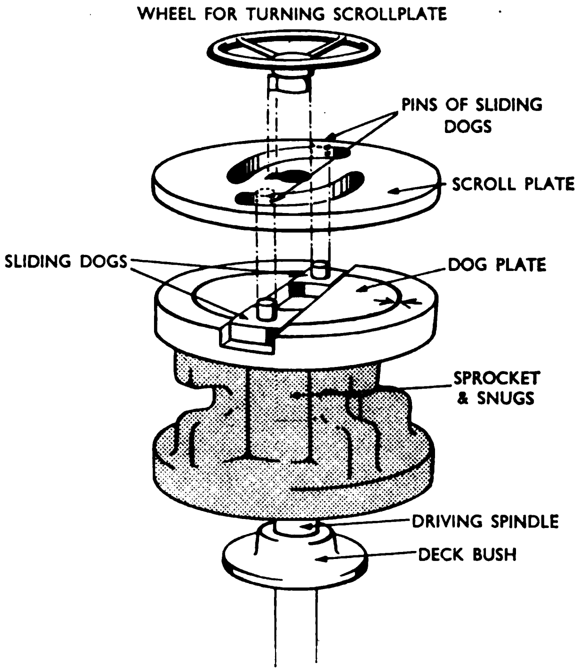


FIG. 9–8. Component parts of a cable holder

slowly turned by the capstan engine until an indicating line on the sprocket head coincides with an indicating line on the scroll plate, when the slots in the sprocket head and dog plate will also be in line. The scroll plate is then turned by a hand lever until its pointer is opposite a pointer marked IN GEAR, in which position the dogs will have moved outwards and locked the dog plate and spindle to the sprocket. When the brake is taken off, the cable holder can then heave or veer cable.

To disconnect the sprocket from its spindle the brake is put on and the scroll plate turned until its pointer is opposite a pointer marked OUT OF GEAR, when the dogs will have moved inwards and unlocked the dog plate and spindle from the sprocket. Cable can then be allowed to run out freely by releasing the brake.

The operation of the brake (fig. 9–9). The brake encircles the base of the sprocket, and consists of a band which is hinged at its middle and has each of its ends connected by links to the arms of a quadrant which can be turned about one of two pivots mounted on a brake-shoe. The movement of the quadrant, shoe, links and band is controlled by a handwheel connected to the quadrant by gearing. The movement of the wheel is recorded by a pointer which moves over a dial marked at three positions, namely, BRAKE TO BRAKE, BRAKE TO FREE and BRAKE TO VEER.

Brake to Brake. When the wheel and quadrant are turned to the position at which the pointer indicates BRAKE TO BRAKE the quadrant rotates about one pivot of the brake shoe and forces the shoe and band against the sprocket in the same direction in which it is tending to revolve (fig. 9–9(i)). Any movement

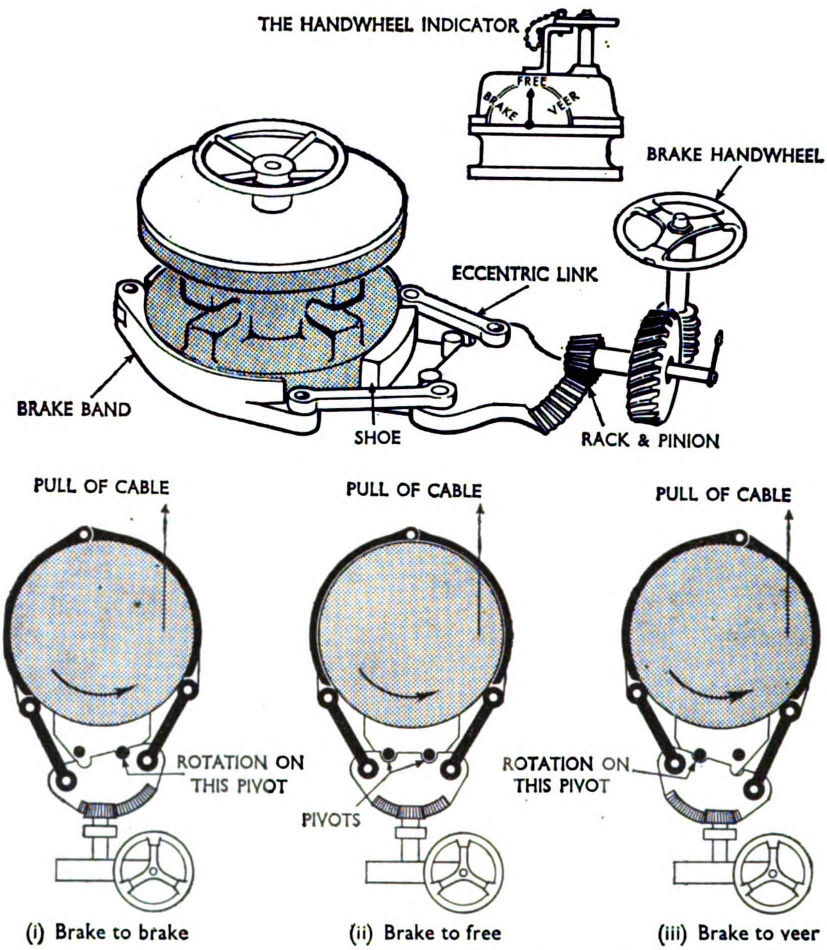


FIG. 9–9. Operation of the brake of a cable holder

of the sprocket in this direction therefore forces the shoe and band into closer contact with itself and therefore applies the brake with greater force than is exerted by the handwheel.

Brake to Free. When the wheel and quadrant are in their central positions the band and the shoe are released from contact with the sprocket so that the sprocket can revolve freely on its spindle, and the pointer then indicates BRAKE TO FREE (fig. 9–9(ii)).

Brake to Veer. When the wheel and quadrant are turned to the position in which the pointer indicates BRAKE TO VEER the quadrant rotates about the other pivot of the brake shoe and forces the shoe and band against the sprocket in the opposite direction to that in which it is tending to revolve (fig. 9–9(iii)). Any movement of the sprocket in that direction therefore tends to remove the shoe and band from contact with it, and the brake is therefore held in contact by the force applied by the handwheel only.

Use of the brake. The brake is used in the BRAKE TO VEER position for stopping or controlling the cable under all normal conditions of the cable running out. It is used in the BRAKE TO BRAKE position to hold the cable when the ship is riding to her anchor or made fast to a buoy, and to arrest or hold the cable in emergency. Many are reluctant to use it in this position because of an erroneous idea that it will probably jam; it will not jam unless the engine is then moved to veer the cable holder. The brake should never be applied when cable is being hove in or veered by the engine, and when the cable holder is connected up it should therefore be set to BRAKE TO FREE.

Combined capstan and cable holder

Fig. 9–10 shows a type of combined capstan and cable holder, fitted in destroyers and frigates, in which the capstan is mounted above the cable holder on the same spindle. The capstan is keyed to the spindle and can also slide up or down it, but the cable holder is not connected to the spindle in any way. The head of the spindle is cut with a screw-thread which works in a nut fixed to the centre of a handwheel keyed to the crown of the capstan, so that when the handwheel is revolved the capstan is raised or lowered on its spindle. A number of dogs project at intervals round the bottom of the capstan barrel, and when the capstan is lowered on to the cable holder they engage in slots cut in the head of the cable holder sprocket, thereby locking the cable holder to the capstan. When the capstan is raised by turning the handwheel the dogs are disengaged from their slots, thereby freeing the cable holder.

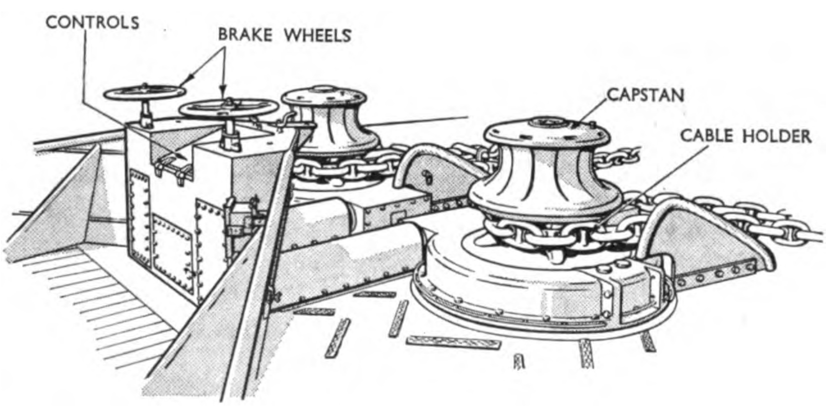


FIG. 9–10. Combined capstans and cable holders

To connect the cable holder to the capstan the capstan engine is turned until the mark on the bottom of the capstan barrel is in line with that on the head of the cable holder; the capstan is then lowered on to the cable holder by turning the handwheel on the crown of the capstan in the required direction, and the dogs then engage in their slots and lock the capstan and cable holder together.

To disconnect the cable holder from the capstan the latter is raised by turning its handwheel, thereby disengaging the dogs from the sprocket and freeing the cable holder.

Each cable holder is fitted with a simple band brake, which bears on the skirt

of the sprocket and is operated by a handwheel. The action of the brake is similar to that of a large cable holder when set to BRAKE TO VEER.

Windlasses

The chief difference between a windlass and a capstan or a cable holder is that the windlass is mounted on a horizontal shaft whereas the other two are mounted on vertical spindles. Although its primary function is to work the bower cables, the windlass is fitted with warping drums for working hawsers and therefore combines in one machine the functions of both capstan and cable holders. Most merchant ships are equipped with some form of windlass, but they are fitted in only the smaller warships because their height above the deck obstructs ahead gunfire at low angles of elevation.

The engine or motor of a windlass is usually situated directly abaft the windlass on the forecastle deck, and for the normal requirements of anchor work both engine and windlass can be operated by one man. Smaller windlasses can usually be worked by hand should steam or electric power fail. Fig. 9–11 shows a typical electric windlass.

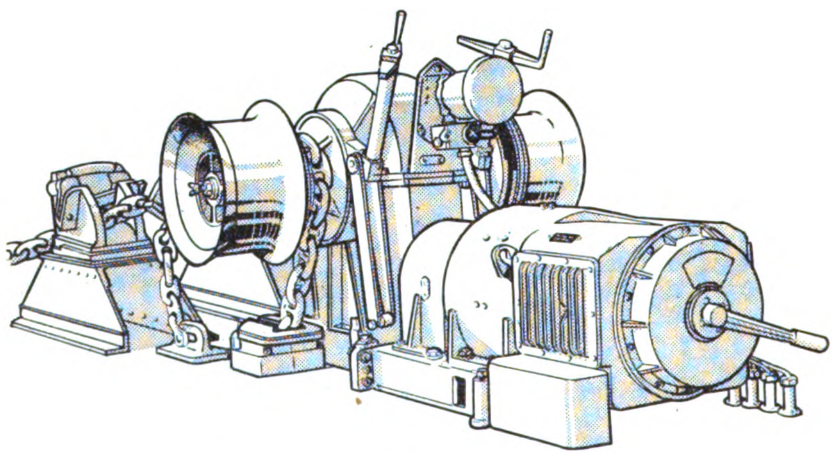


FIG. 9–11. A typical electric windlass

The shaft and warping drums are driven by the motor through gearing. The two sprockets for taking the two bower cables are mounted on the shaft outside the gear wheels, and are called *gypsies;* they are exactly similar to the sprocket of a cable holder, and the joining shackles of the cables must pass over them on the correct slew. Each gypsy can revolve freely on the shaft, or be clutched to the shaft. To connect the gypsy to the shaft the engine is turned until the slots in the gypsy are in line with the dogs, and the wheel inside the warping drum is turned until the dogs engage in the gypsy, and the wheel is then locked. To disengage the gypsy the brake is applied and the wheel turned in the other direction until the warping drum dogs are clear of the gypsy slots, and the wheel is then locked. Each gypsy has a simple band-brake, operated by a handle. The windlass engine is operated by a T handle inserted in a deck fitting and there is an emergency foot-stop close to it.

Motive power

The engines or motors of capstans, cable holders and windlasses are designed to heave in both bower cables simultaneously. Their ability to meet design requirements is tested when ships undergo their acceptance or refit trials.

An electric capstan motor is usually fitted with a slipping clutch in its driving mechanism. It is adjusted to slip when the maximum designed load of the motor is exceeded.

Instructions for periodical inspections of capstans, cable holders, windlasses, and their associated machinery are given in B.R. 3000, *Marine Engineering Manual*, and also in *The Queen's Regulations for the Royal Navy*. These inspections include the foot bearings and deck bushes of the shafts of capstans and cable holders, and the clutch mechanisms of cable holders. Periodic maintenance is also covered by maintenance schedules issued for each item of equipment.

MAINTENANCE, SURVEY AND TESTING OF ANCHORS AND CABLES

Test and maintenance

Before being accepted for service at sea all cable and its associated gear are subjected to a proof load test; the proof loads of different sizes of forged steel and wrought iron cable are laid down by the Navy Department in the manufacturing specifications, but they can be found approximately from the formulae given in Appendix I (page 599). In addition, samples of cable and its associated gear are tested to destruction, in which the minimum breaking strength must not be less than 50 per cent above the proof load; for example, cable having a proof load of 100 tons must not fail under test below a stress of 150 tons.

The strength of cables may eventually decrease through wear, corrosion and fatigue, in the same way as the fittings described in Chapter 6; fatigue is caused chiefly by the battering to which the cable is subjected when running out through the hawsepipe and navel pipe, and when being hove in under strain. Cables are therefore surveyed periodically, and are heat-treated (normalised) at less frequent intervals. The survey should bring to light any deterioration caused by wear or corrosion, and should detect any flaw or crack in a link caused by fatigue or misuse, but it will give no guide to the brittleness of the cable. The survey also provides an opportunity for rectifying minor defects, cleaning and overhauling joining shackles, and transposing the more hardly worked lengths with others so that the whole cable will wear evenly. The periods at which survey, normalising for correction or brittleness, and testing should take place depend on many factors, and are given in B.R. 367, *Anchors, Chain Cables, etc.* It is sufficient to note here that men-of-war in commission are bound by *The Queen's Regulations for the Royal Navy* to survey their cables every nine months for destroyers and below, and every twelve months and in docking periods for cruisers and above (eight months in the case of submarines) and to follow in every respect all other instructions contained in B.R. 367.

When a survey of cable and associated gear is due, the regulations require the Commanding Officer of the ship to appoint two or three officers to carry it

out, and to arrange for them to be assisted by a shipwright. When the ship is in a dockyard port a blacksmith from the dockyard is always employed and a signal requesting his assistance must be sent to the Superintendent of the Dockyard. Certain other gear, such as wire hawsers, must be surveyed at the same time, and a comprehensive report is sent to the Navy Department (Director of Dockyards) by the Commanding Officer if at home, or by the Commander-in-Chief or Administrative authority if abroad, on Form S.194. A duplicate is inserted in the Captain's Ship's Book.

The men employed in the smiths' department of Royal Dockyards have vast experience in all matters connected with the repair and testing of cable and associated gear, and the seaman is advised to visit them to gain first-hand knowledge of the gear on which the safety of his ship so often depends.

Procedure for survey

When berthed in a Royal Dockyard and embarking or disembarking cable, a dockyard slinger and blacksmith must be present, and work must be supervised by an experienced officer.

To prepare for a survey the cable lockers must first be cleared and the cable ranged (i.e. laid out in fleets) on deck, or wherever convenient. If desired to range the cable along the bottom of a dry dock permission must first be obtained from the Superintendent of the Dockyard. Every shackle should be examined to ensure that the pin does not project, and then be broken (i.e. parted). The machined surfaces should be cleaned and greased before reassembly, otherwise the shackles may become difficult to part. The various parts of different shackles are not interchangeable, because each shackle is made as one unit. The dovetail chamber of each shackle should be carefully reamed to remove every particle of the old lead pellet.

Lugged shackles and their bolts should be coated with warm tallow, and their pins rubbed over with stiff white lead.

Every link of wrought iron and some forged steel cables is tapped by a blacksmith to test it for a flaw, and carefully examined. Forged steel cable of 'Tayco' manufacture is not tapped. Should any link be found to have lost more than one-tenth of its original diameter (or one-eighth if the cable is smaller than 2¾ in.) from wear, corrosion or any other cause, the length of cable which includes the link is unfit for sea service and should be returned to the dockyard, where the link will be replaced or the whole length condemned and a serviceable length issued instead.

Swivels should be examined and greased if they are of the box type, or warm tallow poured into the cups if they are of the cup type. All slips, adaptor pieces and associated or spare gear are surveyed at the same time as the cable. The spare gear should be preserved by coating it with boiled linseed oil. Finally, the shackles of cable are transposed as required, to avoid undue wear on any one length, joined up together and re-marked. The inner end of the cable is then made fast to the cable clench in the locker, inspected by the Navigating Officer to confirm that it has been correctly secured, and then the cable stowed below.

Restowing cable. With or without the assistance of a dockside crane, the cable should never be lowered directly down the navel pipe, because it may acquire several unnoticed turns which will result in severe kinking and jamming of the

cable when it is run out on the next occasion of anchoring. It must first be passed round the cable holder. If a crane is used, the cable is lowered on to the forecastle first.

If no power is available the cable must still be passed round the cable holder and eased into the cable locker, using a tackle and joggle shackle. Whenever the movement of the cable is halted—for example, to connect the next length of cable—the brake should be applied and a pinch bar inserted through the link of cable nearest to the top of the navel pipe; the compressor (or riding slip) need not be used unless the work is halted for a long period.

Other maintenance

The Queen's Regulations for the Royal Navy requires that capstans, cable holders and windlasses be turned and lubricated weekly, and that their shafts and deck bushes be examined at each ship refit. In capstans where the capstan head is secured by screws or bolts to a disc keyed to the spindle, the head and disc are to be parted once in every twelve months and the bearing surfaces, keys and screws examined for damage and deterioration from corrosion. In addition, the flukes of all anchors with movable flukes must be moved and lubricated monthly. Form S.194 includes a statement that these requirements have been met.

Heat treatment and test

This can be carried out only by a dockyard specially equipped for the purpose. The work must be included in the ship's *Pink Defect List* in time for it to be carried out when due; i.e. between three and four years for ships of the Fleet. After the cables have been heat-treated (normalised) to remove any brittleness of the metal, they are tested to three-quarters of their proof load. This reduction is necessary to avoid stretching the cables. However, if any links have been renewed or extensively repaired, the portion of the cable affected is subjected to its full proof load. After testing, every link of cable and every part of associated gear is minutely examined.

The normalising of forged steel cable is somewhat different from that of wrought iron cable and requires a higher temperature. Lugless joining and anchor shackles of alloy steel cannot be normalised, so they are only subjected to their proof load test. Spare swivels, lugged shackles, adaptor pieces and other associated gear are normalised with the cable only if they have been used.

Aluminium bronze cable and its associated gear is not heat-treated.

Markings on cable

The manufacturer of the cable can be identified from the initials stamped on one side of the studs, while the year of manufacture is stamped on the other side; in forged steel cable these markings may be on alternate studs only. The links at the end of each length of cable are marked on one side with a broad arrow and the cable number, and on the other side with the number of the testing house certificate, the initials of the proving house, the proof load, and the initials of the overseer. Associated cable gear is stamped in much the same manner.

A record of any heat treatment and retesting is also stamped on all lengths

of cable and associated gear. For example, cable stamped 'AN. Po. 89 12/64 T. 40½' would have been annealed (normalised) at Portsmouth in batch number 89 in December 1964 and tested to 40½ tons, which is three-quarters of the original proof load.

Tests of anchors

Anchors are tested initially to a proof load given in their specifications, and if made of iron they are also fireproofed, which is a process for detecting a flaw in the metal or a bad casting. Anchors are not retested or refireproofed, except on completion of a large refit, unless considered desirable by dockyard officers.

Markings on anchors

On satisfactory completion of the original test the proof load is stamped on the crown of the anchor, also the letter F if the anchor has been fireproofed. For example, an anchor marked 'T35T F Po. 12/64' would have been tested to 35 tons and fireproofed, at Portsmouth, in December 1964. Subsequent examinations, repairs, tests, etc. are stamped on the shank as follows: E—examined; F—fireproofed; R—repaired; T—tested (proof load is included). The initial letter of the dockyard is added to each. The letters REP indicate that the anchor has been repaired under special supervision.

Parting of cable

Should a cable or any of its associated gear part, the broken link or part should be recovered if possible and the fracture covered with tinfoil or other suitable material to prevent rusting. It should then be forwarded to a southern naval dockyard if the ship is in home waters, or to the nearest naval dockyard if abroad, together with a detailed report on Form S.541.

ANCHOR WORK

In Volume I the seaman learnt how a ship is brought to a single anchor and secured by one bridle to a mooring buoy. In this section the standard methods by which anchors and cables are to be worked will be given; for, although ships differ in forecastle layout, standardisation of method throughout the Fleet is essential for safety of both personnel and gear. Volume III gives the ship-handling aspect of this subject.

Terms and expressions used in anchor work

Shortening-in cable. A ship lying at anchor is said to shorten-in her cable when she heaves in part of it; for example, a ship riding to eight shackles of cable might shorten it to three shackles before weighing anchor, or temporarily to reduce her swinging radius.

Weighing anchor is the operation of heaving in cable until the anchor is broken out of the bottom and hove up clear of the water. (*Weigh* must not be confused with *way*, which refers to the motion of a ship through the water.) The anchor is said to be *a'weigh* immediately it is clear of the bottom.

To grow. A cable is said to grow in the direction in which it leads outside

the hawsepipe. When asked, How does the cable grow ?, the reply is given by pointing the arm in that direction, unless it grows vertically, when the report 'Up-and-down' should be given.

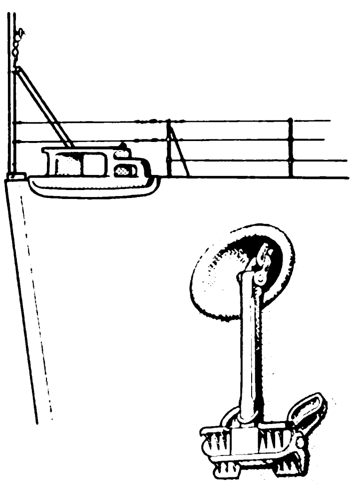
Short stay. The cable is said to be at short stay when it is taut and leads down at a steep angle to the anchor, and a bridle is said to be at short stay when the mooring buoy is hove close under the hawsepipe.

Long stay. The cable is said to be at long stay when it is taut and reaches out well away from the hawsepipe and enters the water at an acute angle.

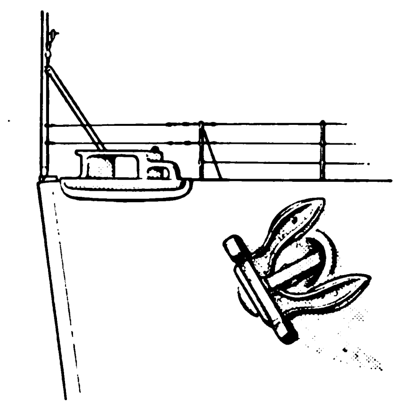
Up-and-down. The cable is said to be up-and-down when it is vertical. When weighing anchor the cable will be up-and-down just before the anchor is broken out of the bottom, and this usually occurs soon after it is at short stay.

Clear or foul anchor. The anchor is reported clear or foul as soon as is it entirely sighted. To be clear the anchor must be hanging from its ring and clear of its own cable and of any obstruction such as a bight of rope or chain picked up from the bottom. This visual sighting does not apply to the modern submarine's anchor.

A'cockbill. An anchor is said to be a'cockbill when it has been eased out of the hawsepipe and hangs vertically by its ring (fig. 9–12).



(i) Byer's anchor a'cockbill



(ii) Anchor stowed in hawsepipe

FIG. 9–12. Anchor a'cockbill and stowed in hawsepipe

Dragging. An anchor is said to be dragging when, instead of holding the ship, the ship drags it along the bottom; this may occur in heavy weather, in a strong current, or when insufficient cable has been paid out. A small amount of dragging on anchoring is necessary, of course, in order to bury the anchor in the sea-bed. The amount of cable to be veered is discussed generally in this section, and more fully in Volume III, Chapter 13.

Anchor coming home means that the anchor is dragging towards the ship as the cable is hove in. When weighing, the ship should always move up to the

anchor, using her engines if necessary, and the anchor should not break out of the bottom until the cable is up-and-down.

To come-to. A ship is said to come-to an anchor at the moment of letting go. The entry in the Log would read: '0900. Came-to with port anchor . . . etc'. A ship has got her cable when she has dropped back on her cable and is riding to it.

To veer cable is to pay or ease out cable from the cable holder or windlass when these are connected to and controlled by their engines; the position of the brake should be BRAKE TO FREE and the order would be 'Veer on power'. It also means to allow the cable to run out by its own weight or strain on the outboard end under control by the cable holder or windlass brake; the position of the brake should be BRAKE TO VEER and the order would be 'Veer on brake'.

To surge is to allow a hawser to ease out by its own weight or by the strain on the outboard end. A hawser slipping round the barrel of a capstan or warping drum is said to surge whether the barrel is stopped or turning to heave in. *Surging when the barrel is turning to veer is dangerous and must never be attempted.*

To snub a cable is to restrain it suddenly when running out by applying the brake. This is damaging to the cable, so it should only be carried out in an emergency.

To range the cable means to haul it out of the cable locker and range it in fleets on the forecastle deck or the bottom of a dry dock, for example.

To bring to is to pass the cable, or a rope, round a cable holder, windlass, capstan or warping drum for heaving it in, veering it, surging it or securing it.

Clear hawse. This term means that the cables are clear of one another when a ship is riding to two anchors.

Foul hawse. A ship has a foul hawse if the cables are crossed or otherwise foul of each other when she is riding to two anchors. If the ship swings 180 degrees she will have a foul hawse, and the cables are then said to have a *cross* in them; another 180 degrees more in the same direction would cause an *elbow* in the cables; a further 180 degrees would cause an *elbow and a cross*, and yet another 180 degrees (making twice round in all) would cause a *round turn.*

To hang cable is to hold it temporarily with a stopper.

A *hanger* is usually a rope which is passed through a link of chain cable or round the bight of a rope to hang it.

ANCHORING AND WEIGHING

The composition of the cable party depends on the type and size of the ship, her forecastle layout, the design of the cable lockers and the type and motive power of her cable holder or windlass. The operation of preparing the anchors for letting go is called *clearing away anchors and cables*, and this is done when approaching the land, whether it is intended to enter a harbour or not.

The clearing away of anchors and cables has been described briefly in Volume I. When all sea lashings have been cast off and other associated gear and fittings removed, both anchors are prepared for letting go. The orders for this operation, and the action taken, are given below (for the port anchor only).

Order	*Action*
'Connect up port'	The capstan engine is manoeuvred to bring the marks of the port cable holder in line, and the shipwright then engages the clutch by turning the handwheel.
'Off brake port'	The shipwright takes off the brake.
'Ease back the screw slip'	The screw slip is started with a tommy bar, or similar tool, and eased back until the cable becomes taut to the cable holder. (This easing back must be carried out to transfer the line of pull from the slip to the cable holder, otherwise the slip or the cable might be unduly strained.)
'Off slips. On Blake slip, slack'	The screw slip and Blake slip are knocked off, and then the Blake slip is put on again after allowing sufficient slack for the anchor to be eased down the hawsepipe.
'Veer port'	The cable is veered until the weight of the anchor is transferred to the Blake slip.
'Stop. Disconnect port'	The shipwright disconnects the cable holder.

Letting go

At the order 'Stand by' the hands below (in hand-stowed cable lockers) are warned to stand clear of the cable and the pin is taken out of the Blake slip; the shipwright, or a seaman if a shipwright is not available, then makes ready with his hammer to knock off the slip. At the order 'Let go' the slip is knocked off. The Cable Officer watches the cable outboard and orders the brake to be applied so that the cable is laid out straight and clear along the bottom and never allowed to pile up on itself. It must not be allowed to grow aft too tautly or the sharp nip at the lower end of the hawsepipe may cause it to part. The way of the ship must always be stopped by her engines and not by the cable.

The task of the Cable Officer is much affected by the course and speed of the ship on letting go, both of which are controlled by the Captain; the speed while anchoring must be low, otherwise the cable will be unduly weakened by fatigue caused by the battering it will receive by running out too fast. H.M. ships normally anchor with headway on the ship, because they must let go in a predetermined, exact position. It is customary to head into the wind or tidal stream when anchoring, but this is by no means obligatory because, provided there are suitable marks ahead of the approach course, allowance can be made for any leeway during the approach. When anchoring head to wind or tidal stream with headway on, the ship will drop back on her anchor after the way has been taken off her, and the Cable Officer must then keep enough strain on the cable to pull the bight out straight as the ship drifts to leeward of her anchor.

When possible, the weather anchor is always used so that the ship will swing clear of her cable. When anchoring in deep water (over 15 fathoms) the anchor is veered under power to within about 10 fathoms of the bottom before it is let go, otherwise the anchor may be damaged on hitting the bottom and the cable may become brittle as it runs out fast, possibly piling up on the anchor and perhaps fouling the flukes or fracturing links.

Amount of cable to be put out

The minimum amount of cable to be used with a single anchor which will ensure that the maximum holding pull of the anchor can be developed is that which is needed to give a horizontal pull on the ring of the anchor in all conditions of wind and stream. It depends upon the magnitude of the holding pull, the depth of water and the type of cable. Assuming that the cable size is selected to provide a working load equal to the maximum anchor pull, then the variation in the amount of cable required over a range of anchor pulls from 0–100 tons is quite small and we can assume that the variants are only depth of water and type of cable.

Approximate formulae which may be used in all circumstances are:

Forged steel cable $n = 2\sqrt{d}$

Wrought iron cable $n = \frac{3}{2}\sqrt{d}$

where n is the number of shackles and d is the depth in fathoms.

If the depth of water requires more shackles of cable than are available, the seaman must remember when the weather deteriorates that his anchor is not providing its maximum holding pull, as described later, and must take more precautions.

NOTE.—The old rule for determining the amount of cable was to multiply the depth of water by a factor ranging from 4 to 8, depending on the type of cable being used. This rule was inaccurate and, in deep water, impracticable, because it did not take into account that the factor should be reduced with increased depth.

A graph showing the minimum amount of cable to be veered to ensure a horizontal pull at the anchor is given in Volume III.

Length of stay and weather. If a ship is anchored for only a short period less cable may be used, provided that the amount is sufficient to give a horizontal pull at the anchor in the prevailing wind and stream. In bad weather there is little advantage in paying out more cable than is required from the formula, because additional cable increases yawing unless a second anchor is used to control the yaw.

Effect of cable

The cable acts as a shock-absorber between the anchor and the ship. The weight of the cable causes it to lie in a catenary between the hawsepipe and the sea-bed. The greater the force (from wind and stream) acting on the ship, the greater will be the distance between the hawsepipe and the anchor, so that the amount of cable lying on the bottom will vary. This cable on the bottom provides a holding pull of two-thirds of the actual weight of the length of cable on the bottom, and this, of course, is added to the holding pull of the anchor. In conditions where there is a likelihood of the anchor dragging, there is unlikely to be any cable lying on the sea-bed and it is therefore safer to consider only the holding pull of the anchor.

Forged steel cable is stronger than wrought iron cable of the same size; therefore for the same proof strength forged steel cable is smaller and lighter

and more cable is required to provide a horizontal pull at the anchor and also the same shock-absorbing effect.

Holding pull of anchor

In all but rock sea-beds an anchor will hold by its flukes until the pull on the cable exceeds the holding pull of the anchor. The holding pull varies with the weight and type of anchor, the direction of the pull in the vertical plane and the nature of the bottom. As soon as the forces acting on the ship raise the catenary so that the pull on the ring of the anchor is above horizontal the efficiency of the anchor is reduced. The percentage of maximum holding pull for an anchor is as follows:

Angle of pull above horizontal (degrees)	*Percentage of maximum holding pull*
5	80
10	60
15	40

A.S.S. type anchors, when subjected to a pull greater than the maximum holding pull, have a tendency to roll, turn over and drag some distance before they begin to grip again. When subjected to pulls in different directions, a when a ship is yawing, this tendency to roll out of the sea-bed is increased therefore it is advisable to use a second anchor to reduce the yaw. The A.C; type anchors are much more stable; they can be hauled and turned through large distances and angles without rolling out of the sea-bed.

Nature of bottom. The nature of the sea-bed has a considerable effect on the holding pull of an anchor, as is seen from the following table showing the mean value of the maximum holding pulls measured in a series of pulls in each type of bed. It should be realised, however, that the value in any bed will vary by as much as ± 15 per cent from the mean because of variations in the nature and compactness of the sea-bed.

APPROXIMATE MEAN MAXIMUM HOLDING PULL (IN TONS) OF ANCHORS WHEN THE CABLE CATENARY IS HORIZONTAL AT THE ANCHOR SHACKLE

Anchor	Weight (cwt)	Very soft mud	Sand and shingle	Sand, shingle and clay	Blue clay
B	190	15	32	47	25
B	160	12	27	39	21
B	120	9	20	29	15
B	16	1¼	2¾	4	2
M	12	1	2	3	1½
A.S.S. ..	95	7½	16	23	12
A.S.S. ..	45	3½	7½	11	6
A.S.S. ..	34	2¾	5¾	8½	4½
A.C.14 ..	52	16	20	32	34
A.C.14 ..	32	10	12	19	20
A.C.12M ..	28	8½	10	13	13
A.C.12M ..	19	5¾	7	8	8
A.C.16A ..	—	—	—	—	—
A.C.17 ..	—	—	—	—	—

B—Byer's
M—Martin's
A.S.S.—Admiralty Standard Stockless
A.C.—Admiralty Cast

	Examples
Very soft mud	Tail of the Bank (Clyde)
Sand and shingle	Solent and Bigbury Bay
Sand, shingle and clay	Ardrossan Bay
Blue clay	Portland

Pull on the cable. In order to assess whether an anchor will hold it is necessary to estimate the pull on the cable at the ship and to compare it with the holding pull of the anchor. The forces acting on the ship are due partly to the wind above the waterline and partly to the stream acting upon the hull and cable below the waterline. The table below shows the pull on the cable for varying speeds of wind, with a constant tidal stream of 4 knots, *when the ship is lying head to wind and stream.* The additional pull when a ship yaws is considerable; for example, tests on a frigate have shown that only 10 degrees of yaw increases the pull by 60 per cent. Therefore the table should be used only as a guide.

PULL ON THE CABLE (IN TONS) FOR VARYING WIND SPEEDS AND CONSTANT STREAM SPEED OF 4 KNOTS

	Beaufort Wind Scale (speed in knots)			
	5 (18)	8 (37)	10 (52)	12 (68)
Carriers				
Eagle	26	34½	45½	61
Centaur	15	20½	27½	37
Cruisers				
Tiger class	12½	15½	20	26
Destroyers				
County class (G.M.)	9	12	16	21
Daring class	7	8½	10½	13½
CA class	5	6¼	8	10¼
Frigates				
Tribal class	4	5½	7½	10¼
Whitby class	5¼	6¾	8½	11
Leopard class	4¾	6½	8½	11¼
Blackwood class	3¾	5	6½	8¾
Submarines				
Porpoise class	2¾	3	3¼	3¾

The tables of holding pull and pull on the cable show that in a *County* class destroyer the 52 cwt A.C.14 anchor should hold in all but very soft mud in a wind of 68 knots and in a stream of 4 knots when the ship is lying head to wind and stream. If the ship then yaws only 10 degrees the anchor may not hold in any bed.

Conclusion

Although the A.C. type anchor is undoubtedly more efficient than the A.S.S. type, the normal precautions of coming to short or immediate notice for main engines, setting anchor watch and letting go a second anchor to reduce yawing must always be taken in bad weather.

Securing cable

When the ship has dropped back and is riding by her cable the Cable Officer reports that 'the ship has got her cable'. Then the Captain will order the cable to be secured. The Cable Officer then orders the cable holder to be connected, and adjusts the length of cable to the amount ordered by the Captain. It is customary in the Royal Navy to secure the cable so that the joining shackle of the ordered number of shackles lies just above the waterline; for example, if the Captain orders six shackles to be out, the sixth joining shackle would be veered to the waterline. On the other hand, there is much to be said for securing with the joining shackle just abaft the Blake slip, because the cable can then be parted at this shackle and slipped quickly in emergency; also, if two anchors are down it is much easier to clear a foul hawse when the cables are in this position.

H.M. ships fitted with a cable holder ride by the brake of the cable holder, with the riding slip or compressor acting as a preventer. To secure cable in this way, the preventer is first put on, and the cable then veered slowly until just before the preventer takes the weight of the cable. The brake is then put on, either by being screwed up hard or applied *brake to brake* (according to the type fitted), the cable holder is disconnected and the Blake slip put on slack.

H.M. ships fitted with a windlass ride by the brake of the windlass, with the Blake slip and guillotine (if fitted) acting as a preventer. Neither riding slip nor compressor is fitted.

The other bower anchor is always left ready for letting go.

A man-of-war may occasionally have to get under way at a moment's notice; then she would ride by her Blake slip, with her cable broken abaft it and a buoy and buoy-rope bent to the outboard part. To get under way the cable is slipped and buoyed, to be recovered later.

Precautions in bad weather

If the ship is lying at single anchor, and if there is sufficient searoom to leeward, more cable may be veered. The cable holder must be connected while veering, because, if the cable were allowed to run out by the brake, the snatch on the cable caused by the weight of the ship suddenly coming on it after drifting astern and taking up the slack might weaken the hold of the anchor. A second anchor may be let go, and then both cables veered.

Yawing. A ship, especially one with a high forecastle, usually yaws considerably to each side of the wind when lying at single anchor in bad weather (fig. 9–13). At the end of each yaw the ship is particularly liable to drag her anchor, because she first surges ahead and then falls back on her cable, thereby imparting a jerk to the anchor. Such a yaw may be checked by veering the second anchor underfoot at the middle of the yaw and so that it just reaches the bottom. If the weather is so bad that a second anchor is likely to be required for safety, it is better to let it go at the end of the yaw away from the first anchor and to veer both cables so that the ship rides with one anchor at long stay and the other at short stay.

Anchor watch should always be set in bad weather. This watch consists of an officer on the bridge and a special party on or near the forecastle ready to watch

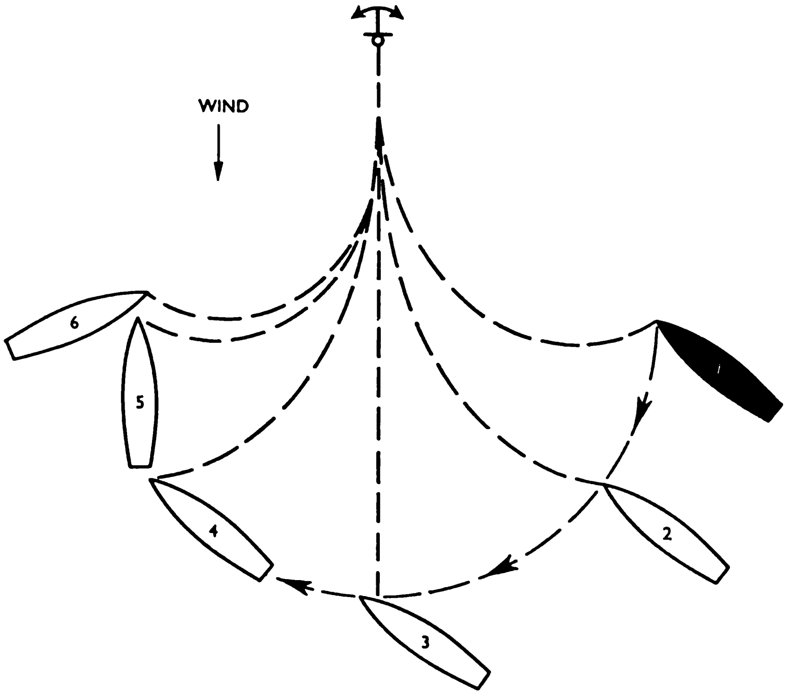


FIG. 9–13. Yaw of a ship at single anchor in a strong wind

and work the cable. Power should be on the capstan and main engines, and the sea dutymen should be closed up at the wheel and telegraphs. Dragging of the anchor can be detected by taking frequent compass bearings on shore objects, by a hand lead lowered to the bottom, or by the behaviour of the cable. When the anchor is dragging, the cable usually tautens and slackens alternately in a marked manner and vibration can be felt in it as the anchor is dragged along the bottom.

Shortening-in and weighing single anchor

As when clearing away, power must be ordered on the capstan, the cable party piped to muster on the forecastle, and, in some ships, hands stationed at the cable locker. The appropriate cable holder is connected, then the compressor or riding slip, the Blake slip and the brake are taken off. Hoses are rigged and brooms provided for washing the cable as it comes in; one hose is usually fitted with a nozzle and used to throw a jet of water on to the cable outboard, and a second hose without a nozzle is used inboard with the brooms. Some modern ships have cable-washing sprayers in their hawsepipes. Paint is provided for touching up the marking of the cable.

When ordered to shorten-in, or to weigh, the Cable Officer gives the order to heave in. He must watch how the cable grows and indicate this to the Captain so that the ship's engines may be used to assist the capstan engine if necessary. If the cable grows sharply round the stem it must be hove in very slowly and

with great care, because when subjected to such a bad nip the links may easily be strained and even part; also, if lugged shackles are fitted they may foul the stem and open. Cable growing under the ship must be treated with similar care. As the cable comes in the mud on it is washed and scrubbed off by the cable party, the joining shackles and appropriate links are repainted, the wire strands marking the joining shackles are renewed where necessary, and the hands below see that the cable stows correctly in the locker if it is not self-stowing. Cable which is not properly cleaned will soon advertise itself by its smell. The cable should always be cleaned with particular care in tideless harbours with a muddy bottom.

'Up and down', 'Anchor a'weigh', and 'Clear anchor' are reported in due course to the Captain, and the anchor is then hove in and either secured or prepared for letting go again.

Weighing by centre line capstan (fig. 9–14)

This is one method of weighing an anchor in cruisers and above when a cable holder is defective. To bring a cable to the capstan a slip is first put on the cable, and then sufficient cable to pass round the capstan is hauled up from the cable locker and hung at the navel pipe by passing a bar through one of the links and laying it across the navel pipe. The bight of the cable is taken off the cable holder and then passed round the after side of the capstan, and led before and outside the rollers on the opposite side of the ship and thence to its navel pipe. When the cable is brought to the sprocket care should be taken to ensure that it is correctly fitted to the snugs so that the joining shackles will pass round them on the correct slew.

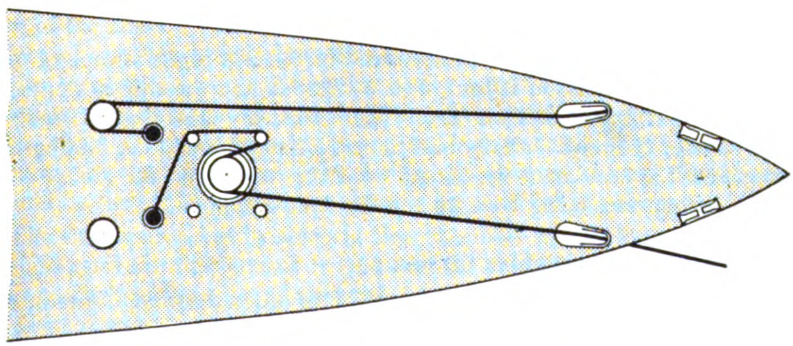


FIG. 9–14. Lead of cables for weighing bower anchor by capstan

Weighing by deck tackle (fig. 9–15)

This method of weighing anchor can be used if the capstan engine breaks down; though not usually so effective as weighing by centre line capstan, it is the only alternative available. The deck tackle is usually a large three-fold purchase, its actual size depending on the size of the ship. In small ships this tackle is kept rove; but in larger ships it is rove only when required.

The standing block of the tackle is secured to a deck clench fitted as far aft as possible on the forecastle, and the moving block is made fast to the cable

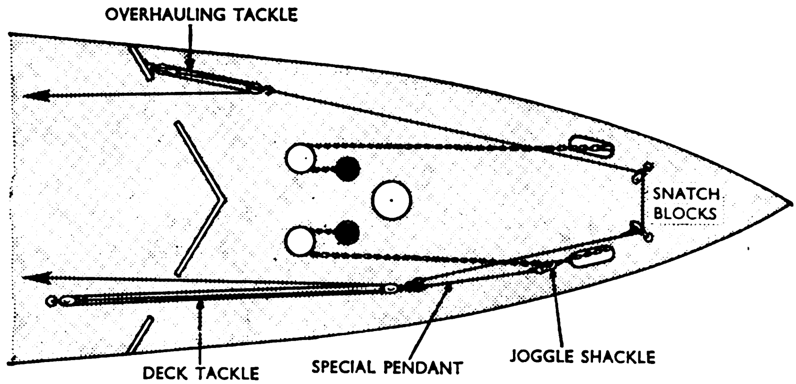


Fig. 9–15. Weighing by deck tackle

with a joggle shackle and a short wire pendant. As long a scope as possible is obtained between the blocks, but the moving block must be kept clear of obstructions. Handspikes are provided for steering the moving block clear of obstructions and preventing the tackle from twisting. When all is ready the fall is manned and hauled away until the tackle is two blocks; the weight of the cable is then taken on the screw slip, the joggle shackle removed, and the moving block hauled forward as the tackle is overhauled; with very large deck tackles a special overhauling tackle must be rigged (fig. 9–15). The joggle shackle is again put on the cable and a further fleet hauled in, this operation being repeated as often as required.

Clearing a foul anchor

An anchor may come up foul of its own cable or of a bight of rope or chain picked up from the bottom. If foul of its own cable and the ship is stopped, it is best to let go the anchor again as it will then usually clear itself. If foul of a bight of rope or chain it is usually best to pass a hanger round the fouling bight and then veer the cable until the hanger takes the weight and the anchor comes clear, the anchor then being hove up and the hanger slipped.

Securing anchors and cables for sea

The anchors must not be secured for sea until ordered by the Captain, who, under normal conditions, will require both anchors to be ready for letting go until the ship is clear of the harbour. Then it must be done thoroughly or the anchors will work loose in a heavy sea; and it must be done quickly, because there is usually little time available before the ship reaches the open sea.

To secure the anchor it is hove up carefully into its hawsepipe, the screw slip is put on and screwed up by hand, and the cable is then veered to the slip to give a correct line of pull. The screw slip is then hove up as taut as possible with long tommy bars or a large spanner, and a short bar should be lashed in place to prevent the slip from easing back on its thread; at the same time the brake is put on and the cable holder disconnected. All slips, compressors and anchor strops are put on, and the cables are lashed together to prevent them from banging and chafing the deck as the ship rolls. The bonnets are replaced

on the navel pipes, and hawsepipes where fitted, and their shutters are lashed to the cable and caulked in place with oakum. Finally, everything movable on the forecastle should be well lashed, or it may have to be secured later under difficult and dangerous conditions. The cables leading down from the navel pipes into the cable lockers should be securely lashed to prevent them from banging noisily against the sides of the navel pipes as the ship rolls and pitches.

MOORING AND UNMOORING SHIP

A ship can be moored either with a *running moor*, in which the first anchor is let go and the ship then continues to go ahead on her course to drop the second; or with a *dropping moor*, in which the ship stops to let go the first anchor and then drops back on it to let go the second. The running moor is usually employed in the Royal Navy, because greater accuracy of position can be achieved. The amount of cable on each anchor should be not less than between four and five times the depth of water, and for a heavy ship a minimum of five shackles (75 fathoms) is usual.

Running moor

Mooring berths are arranged so that ships can moor and unmoor without danger of grounding or fouling adjacent ships, no matter what may be the direction of wind or stream. The line of anchors is usually selected by the senior officer, taking into account the direction of the prevailing wind or stream. Individual ships then mark the intended position of each anchor on the chart. The distance between the two anchors can be estimated as being equal to the sum of the amount of each cable out less 8 to 10 fathoms. This allows for the height of the hawsepipe above the bottom and also for a little slack in the cables to enable them to be hauled easily round the bows in the process of mooring. For example, if mooring with four shackles (60 fathoms) on each cable, the distance between anchors is 110–112 fathoms. When mooring at low water where there is a large range of tide, the distance between the two anchors should be further reduced by an amount equal to half the range.

The ship approaches by steering along the line on which she is to let go her anchors, and the first anchor is let go in the predetermined position by order from the bridge. The second anchor is let go by order from the bridge when the ship has reached the correct position, or by the Cable Officer when the correct amount of cable is outside the hawsepipe of the first anchor. Since a ship when mooring almost always approaches into the wind or stream (whichever has the greater effect on the ship), it is the second anchor that is the riding anchor when the ship is middled. The first anchor is usually the one on the windward side (i.e. the weather anchor), so that the ship swings clear of her cable when middling.

For convenience it will now be assumed that the ship approaches with the wind on the starboard bow and is mooring with five shackles on each cable, that the cable holders can be worked independently by the capstan engine, and that the starboard anchor was let go first; therefore the port anchor is the riding anchor when the ship is middled.

As soon as the way is off the ship the starboard cable holder is connected and

the starboard cable hove in, and the port cable allowed to run out a few fathoms at a time under the control of the brake, until the fifth joining shackle of each cable lies on deck abaft the slips. If the port cable is not laid out straight and taut its fifth joining shackle will be outboard before that on the starboard side is hove in; on the other hand, if it is laid out too taut the port anchor may be dragged and the moor will be very slack. The two half-shackles in the middle of each cable may be used to adjust the amount of cable on one anchor if the moor is too slack or too taut.

A slip is put on each cable, the brakes of both cable holders are put on, and the starboard cable holder is disconnected. Selection of the best slip for this purpose depends on the layout of the forecastle; with a taut moor the screw slip is the most convenient, because it is closer to the hawsepipe.

In a *dropping moor* the ship comes to with her first anchor, and when riding to the appropriate length of cable the second anchor is let go. The cables are then middled as for a running moor.

The *mooring swivel* (fig. 9–4) has two legs at each end, one of which has an odd number of links and the other an even number. The legs with the odd number of links are always joined to the starboard cable, and those with the even number to the port cable; this serves to distinguish the cables when unmooring.

Inserting the swivel. Assuming that the ship is riding by the port cable, the mooring swivel is placed alongside the riding cable abreast the fifth joining shackle. At the order 'In swivel' from the bridge the port (riding) cable is broken and the swivel inserted. The port cable holder is then connected and hove in to take the weight off the slip, and the brake is then put on and the cable holder disconnected. The starboard cable is now broken and the *mooring pendant*, which is a wire rope of sufficient length and strength to handle the cable, is rove down through the port hawsepipe, up through the starboard hawsepipe and secured to the *inboard* part of the starboard cable with a joggle shackle at three or four links from its end; these links are then stopped to the mooring pendant. The starboard cable holder is now connected and the mooring pendant brought to the capstan. Then, by veering the starboard cable holder and heaving in with the capstan, the inboard part of the starboard cable is hauled round the bows; the capstan being of greater diameter than the cable holder, it will heave faster than the latter can veer, and so the pendant must be surged frequently to avoid putting too great a strain on it. When abreast the *inboard* end of the swivel the stops securing the links to the mooring pendant are cast off and the last link is shackled to the appropriate leg of the swivel. The capstan is then veered until the weight of the starboard cable is taken, through the swivel, by the port cable holder, and the mooring pendant is then cast off and unrove.

The port cable holder is now connected, and the port slip is knocked off and hauled clear; then, by heaving in on the starboard cable holder and veering on the port, the swivel is hauled round the bows and up through the starboard hawsepipe. When abreast the slip the remaining leg of the swivel is shackled to the outboard part of the starboard cable, and the starboard cable holder is hove in a bit further to take the weight of the starboard cable off the slip, which is knocked off and hauled clear. The swivel is then veered outboard until it is just above the water and the cables are secured.

It is usually possible to anticipate which will be the riding cable, and before entering harbour the swivel should be placed on the appropriate side and the mooring pendant rove and stopped clear of the cable.

The strain on the cable of a moored ship in bad weather can be eased considerably by veering the swivel to the bottom, thereby lessening the possibility of the ship dragging her anchors; when this is done the swivel should be sighted daily.

Unmooring

A ship is unmoored by taking out the swivel, shackling the inboard and outboard parts of each cable together again, and then weighing one of the two anchors. The swivel is removed by reversing the procedure for inserting it. Again assuming that, as is usual, both cable holders are driven off the capstan engine, both are now connected, one to heave and one to veer; and, assuming that the ship is riding by her starboard cable, the swivel is then hove inboard through the port hawsepipe. The outboard part of the port cable should now be put on the slip and then unshackled from the swivel; but if the parts lie awkwardly the slip can be put on the starboard cable instead, thereby changing anchors. (In either case a parting strop will probably be needed to separate the parts of the cable.)

The swivel is then hove round the bow and up through the starboard hawsepipe, the slip is put on the outboard length of the starboard cable, and a hanger is rove on the inboard part of the port cable (which is still attached to the swivel). The starboard cable holder is then veered to transfer the weight to the slip and the hanger, and all parts are unshackled from the swivel. The two parts of starboard cable are then joined up and the swivel hauled clear. The hanger is then cut, thereby allowing the end of the inboard part of port cable to run out and then be hove in its own side, but if the cable is heavy (above 2½-in.) it should be tailed with a rope and joggle shackle and eased through the hawsepipe. The port cable is then also remade by shackling the inboard and outboard parts together. When unmooring in a strong wind or a tideway, however, it is safer to connect the non-riding cable before removing the swivel from the riding cable, thereby ensuring that both cables are not broken at the same time. In the above example, after the mooring swivel has been hauled in on the starboard side the inboard end of the port cable is unshackled from the mooring swivel, hauled in through the port hawsepipe, and shackled to its outboard part. The mooring swivel is then removed from the starboard cable and the latter remade.

Weighing the first anchor. The non-riding or lee anchor is always weighed first, by veering the riding cable and heaving in the non-riding cable until the lee anchor is a'weigh. The lee anchor is then hove right in and either secured or prepared for letting go, and the riding cable is shortened in ready for weighing.

Signals displayed when working cables

When working cables, direct telephonic communication is established between the bridge and the forecastle, and, in addition, visual signalling is used between the forecastle and the bridge to indicate the state of the anchors and

cables. By day this is done by hand flags and at night by flashing with a dimmed light, using the following code:

Numeral flags 1 to 0 indicate the number of the particular length of the cable which is being worked through the hawsepipe;

'Uniform' horizontally indicates 'cable is up and down' (by flashing —UD);

'Uniform' vertically indicates 'anchor is a'weigh';

'Alfa' vertically indicates 'clear anchor';

'Negative' vertically indicates 'foul anchor';

'Charlie' horizontally indicates 'anchor clear of the water' (by flashing—CW);

'Charlie' vertically indicates 'anchor secured'.

The following example is given to describe the use of the numeral flags when working cable. As the anchor is let go *flag 1* is held aloft to indicate that the first shackle of cable is running out through the hawsepipe. As the joining shackle between the first and second shackles of cable passes through the hawsepipe *flag 2* is held aloft, thereby indicating that the second shackle of cable is passing through the hawsepipe. The passage of each successive shackle of cable is indicated in a similar manner. The same applies when heaving in; when, for example, the joining shackle between the third and fourth shackles of cable passes up through the hawsepipe, *flag 4* is lowered and *flag 3* is held aloft.

To indicate progress in working cables to other ships in the vicinity 'Uniform' is hoisted at the yard-arm on the appropriate side and used as shown in the following table.

Operation	*Progress*	*Signal*
Anchoring	'Anchor let go'	At the dip on appropriate side
	'Cable veered correct amount'	Close-up
	'Cable secured'	Hauled down
Mooring	'Anchor let go' ('port' or 'starboard' may be used to indicate side)	At the dip on appropriate side
	'Cable middled'	Close-up
	'Cable secured'	Hauled down
Weighing	'Am heaving in' (when unmooring, 'port' or 'starboard' may be used to indicate side)	At the dip on appropriate side
	'Anchor a'weigh'	Close-up
	'Ready to proceed'	Hauled down

NOTE.—By night, a white light is used instead of 'Uniform' and is worked in the same manner.

Captain's anchor flags. These consist of two small hand flags, one red and one green, with a white anchor design on each, which are used by the Captain to indicate the exact instant at which to let go the port and starboard anchors respectively.

Example of use of anchor signals. The following example shows the cable

signals used by a ship in daylight when coming to with a single anchor. The Captain shows the red anchor flag from the bridge, meaning 'Stand by to let go port anchor', and this is repeated by the Cable Officer. 'Uniform', made up ready for breaking, is hoisted at the dip at the port yard-arm. The Captain lowers the red anchor flag smartly, whereupon the slip is knocked off the port cable and the anchor let go. 'Uniform' is broken at the dip at the port yard-arm. The cable numeral flags are shown on the forecastle as the cable runs out, and 'Uniform' is hoisted close-up when cable is veered the correct amount, and hauled down when the cable is secured.

To clear a foul hawse (fig. 9–16)

The non-riding cable is hung outboard below the foul, then broken inboard, and the foul is cleared by passing the free end of the non-riding cable round the riding cable in the reverse direction to that of the turns; only half a turn, however, should be taken out at a time. A detailed description of this operation is given below, in which it is assumed that the ship is riding by the starboard cable and that there is a round turn to be cleared.

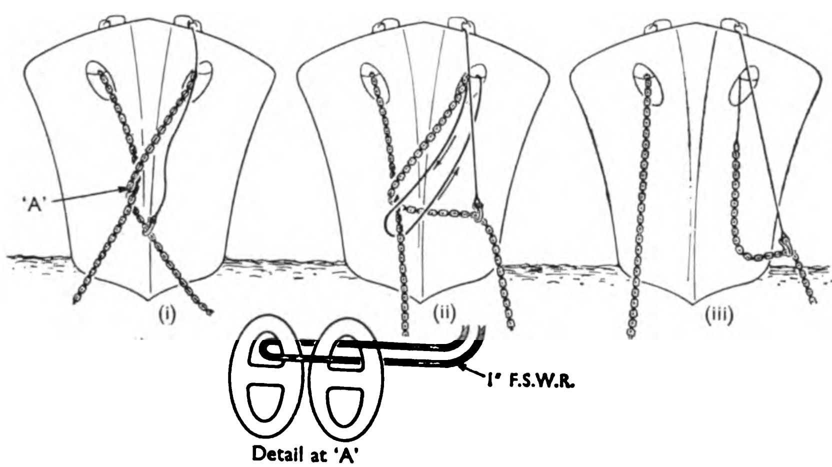


FIG. 9–16. Clearing an elbow of a foul hawse

If the turn is submerged the starboard cable is hove in to bring the turn to a convenient height above water, and the two cables are lashed together just below the turn to prevent the turn slipping down the cables. With heavy cable there is a danger that when the lashing is cut after the hawse has been cleared the two cables may spring back and injure whoever cuts the lashing. To obviate this possibility it is best to lash the cable by reeving a length of one-inch F.S.W. rope through the links, as shown in the inset in fig. 9–16, and then to belay the two ends inboard, ensuring that the rope does not take the weight of the cable while the hawse is being cleared. The cables can then be unlashed from inboard by unreeving the rope.

A strong rope, such as the picking-up rope, is led outboard through the port hawspipe or a convenient fairlead and attached with a joggle shackle to the port

cable below the turn (fig. 9–16(i)); it is then brought to the capstan and hove in to take the weight of the cable. The port cable is hung inboard or put on the screw slip, and then broken (the advantage of securing cable with the joining shackle on deck will now be evident). A rope, called the *messenger*, is now passed out through the port hawsepipe, dipped round the starboard cable in the opposite direction to the turn to be cleared, brought up again through the hawsepipe, and tailed on to the end of the outboard part of the port cable (fig. 9–16(ii)). The slip is knocked off and the messenger hove in (fig. 9–16(iii)); if necessary, the picking-up rope can be stoppered and the capstan used. If the cable is heavy (above $2\frac{1}{2}$-in.) it is advisable not to let the end run out through the hawsepipe because of the battering it would then receive, but to ease it out by a rope fitted with a strop and toggle or any suitable slipping device. When half a turn in the cables has been cleared the messenger is stoppered, its end dipped again round the riding cable, and again hove in; this will clear the remaining half-turn. The end of the port cable is now hove back into the hawsepipe and the cable is joined up again. The picking-up rope is eased up and cast off, and the lashing is cut or slipped from inboard.

Pointing ship

In an anchorage where there is little or no current or tidal stream, and in reasonably calm weather, a ship may be pointed to lie at an angle with the line of her cable by putting a spring on her cable.

First heave in a shackle or so of cable. Now lead a heavy hawser out through the aftermost quarter fairlead and thence forward and outboard of all, and shackle it with a joggle shackle to the cable outboard of the hawsepipe, thereby forming the spring. Then belay the hawser and veer the cable, and the ship's head should pay off away from the side on which the spring is rove until pointing in the required direction, when the cable should be secured. It may be necessary to use the rudder to give the ship an initial cast in the required direction.

BUOY WORK

Volume I contains a brief description of a ship securing to a buoy by a single bridle; here it is intended to explain to the seaman the various ways a ship can be secured to either one or two buoys. The shiphandling aspect of this subject is given in Volume III.

SECURING TO A BUOY

A ship is usually secured to a buoy with two bridles of cable, both of which are provided from one of her two bower cables, thereby leaving the other anchor and cable ready for letting go if required. The standing bridle consists of a convenient length of cable detached from the bower cable, its inboard end being held by bitts, bollards and Blake slip according to the layout of the forecastle. The working bridle is the remainder of the bower cable left rove round the cable holder or windlass.

The ship approaches the buoy with her bridles and picking-up rope ready

for use. In most ships the bridles lead through the stem hawsepipe or bullring, but in a ship with no stem hawsepipe or bullring they must pass through a bower hawsepipe, which necessitates catting one anchor. The picking-up rope can be taken through a separate fairlead, but the best lead is usually through the hawsepipe or bullring, with the bridles. As far as possible neither bridles nor picking-up rope should be allowed to show outboard until just before reaching the buoy.

On arrival at the buoy a boat is used to make fast the picking-up rope to the buoy shackle, the *buoy jumpers* being carried in her for this purpose; these men must then be taken off the buoy as the ship heaves in the picking-up rope. When the buoy has been hauled close up to the stem the buoy jumpers man the buoy, and the ends of the bridles with their securing-to-buoy shackles are lowered to them and they secure the bridles to the buoy shackle or to its reducing links. Because the picking-up rope cannot haul the buoy close up under her hawsepipe or bullring, particularly if there is a strong wind or current, some means must be found to get the ends of the bridles sufficiently far forward to be lowered to the buoy. The ends of the bridles of small ships can be manhandled forward for this purpose; but those of large ships must be triced up in bights at a suitable position before the hawsepipe by *bullropes* made fast to the bridles at two or three links from the ends so that the ends can be lowered to the men on the buoy.

When the bridles are shackled on, the picking-up rope is veered until slack and cast off, hauled inboard and stowed away. No man should be allowed on the buoy while the picking-up rope is veered or hove in, and, for obvious reasons, the buoy jumpers must always wear lifejackets.

Catting the anchor

As when clearing away, the anchor is eased about one foot out of the hawsepipe by the cable holder. The catting pendant is now rove over the clump cathead, up through the hawsepipe, and secured to the ring of the anchor by the special catting shackle; it is then brought to the capstan so that it can be hove in as the cable holder veers. In ships where the cable holders are driven by the capstan engine, the capstan heaves in faster than the cable holder veers, so the catting pendant will have to be surged while transferring the weight of the anchor from the cable to the catting pendant, particularly during the initial stage of the operation and before much strain comes on it. The cable is therefore veered, and the pendant surged, until the anchor is just clear of the water: the pendant is then backed up and the anchor hove up to the cathead, where its weight is transferred to the special chain sling, which is first passed through the ring of the anchor and then held by a Senhouse slip. Any slack in the cable is then taken down, the cable is put on the screw slip and broken at the half-shackle, and any spare cable is ranged neatly on deck.

To prepare the bridles

The standing bridle is prepared and ranged first, followed by the working bridle. The cable holder is connected up, the cable is broken (in a small ship abaft the swivel, and in a large ship at the half-shackle), and a securing-to-buoy shackle is shackled to its end. Sufficient cable to reach from the securing position

nearly to the waterline is ranged on deck, and the cable secured; the best length for the standing bridle is found only by trial, after which it is usual to mark the cable at this position. The remainder of the shackle or the half-shackle is then ranged on deck, the cable is again broken, the second securing-to-buoy shackle is shackled to its end, and the working bridle is ranged so as to match the other for length.

The outboard ends of the bridles are ranged differently in large and small ships. In a small ship the end of each is passed a few feet through the stem hawsepipe or bullring and neatly laid back inboard, and on approaching the buoy the end is run out so that its shackle hangs just above the water. In a large ship the outboard ends of the bridles are placed in the hawsepipe and temporarily hung there. The bullropes are rove out through the bow fairlead, up through the hawsepipe, and then secured to their bridles at the second or third links from the securing-to-buoy shackles; the bullropes are usually tailed at their inboard ends by small tackles. On approaching the buoy the bridles are started so that they run out and hang down in a bight with the outer ends held by the bullropes; the height of the bights above the water can then be adjusted by tackles tailed to the bullropes.

Sending the picking-up rope to the buoy

Each ship has her own method of sending the picking-up rope to the buoy; the principles involved in the three usual methods are described below. Whenever part of the picking-up rope is taken in a boat, the end with the hook and strop attached must be passed in to the head-sheets with sufficient slack for the buoy jumpers to make it fast to the buoy; when all the rope is in the boat the remainder must be coiled clear for running in the stern-sheets. The picking-up rope is always made fast by passing the strop through the buoy shackle and then placing it on the spring hook.

Whichever method is used the boat should be lowered in plenty of time to ensure that she gets to the buoy well in advance of the ship. The coxswain must be careful never to let his boat get between the ship and the buoy or across a tautening picking-up rope; and whenever lying off (while the ship heaves in the picking-up rope, for example) he should always keep his boat pointed at the buoy, ready to go alongside it immediately when called. As stated previously, men should always wear lifejackets while on the buoy; lifelines should be worn only with great discretion, as there is a danger of their fouling the buoy and pulling the men under water.

First method. A heaving line is bent to the picking-up rope and taken in the boat to the buoy; the picking-up rope is then hove out by the buoy jumpers and made fast to the buoy shackle; it is important not to pay out more than the buoy jumpers can comfortably handle. This method is very quick, but requires the ship being brought close to the buoy.

Second method. The end of the picking-up rope is passed into the bows of the boat and the bight is held by a hanger or chain check stopper secured aft in the boat; the boat then makes for the buoy. The distance that can be reached by the boat will be increased if a few fathoms of the picking-up rope are coiled down in the stern-sheets; then, when further headway becomes difficult, this slack rope is eased out under control, thereby enabling progress to be continued.

It is important to head correctly for the buoy in the first place, due allowance being made for wind and stream, because once away from the ship the heavy bight of picking-up rope astern of the boat prevents her from altering course.

Third method. The boat takes all of a 2-inch rope coiled in the stern. As the boat passes under the forecastle, one end is passed inboard and secured below the spring hook of the picking-up rope and the strop is stopped to the rope. The boat approaches the buoy, paying out the rope; places the jumpers on the buoy; passes the end of the rope through the buoy shackle and secures it in the stern. The boat then moves away from the buoy, thereby hauling the picking-up rope towards the buoy while the ship pays it out. When the strop passes through the buoy shackle the stops are cut and the strop placed on the hook. The boat then recovers the rope and buoy jumpers before the picking-up rope is brought to the capstan.

Securing head and stern to buoys

Here, again, each ship has her own methods, and the best way to approach depends on wind and stream. The ship is secured to the head buoy in the manner already described, but a second picking-up rope must be sent from aft to the stern buoy. After shackling on the bridles forward they must be veered a considerable amount if the berth is designed for a longer ship, so that the ship can be dropped astern and the stern hawsers secured to the after buoy. The bridles are then hove in and the stern hawsers paid out to middle the ship between the two buoys and then secured. The method usually adopted for veering the bridles is to break the cable on the anchor kept ready for letting go and tail it on to the standing bridle, the slack then being taken down and both bridles veered together; an alternative is to hang the standing bridle at its normal length and put on the Blake slip so as to allow a very long scope; when the bridles have been shackled on, the hanger is eased out until the standing bridle is held on the Blake slip. The remainder of the operation with the working bridle is then carried out, and the standing bridle, which is hanging slack, is then hove in and secured as convenient.

Scope of bridles

Bridles of equal scope have a tendency to knock together in bad weather. Not only is this bad for the cable, but there is a risk of dislodging the pins of shackles. It is therefore advisable to arrange a slight difference in the catenary of the two bridles, with the working bridle the shorter.

SLIPPING FROM A BUOY

A sliprope is rove between the ship and the buoy, so that the bridles can be cast off and the ship held by it until the order is given to slip.

The sliprope is usually the other end of the picking-up rope and is fitted with a soft eye. It is rove out through a convenient fairlead, *down* through the buoy shackle so that it will be unlikely to foul it when slipped, then in through another fairlead and put on to a slip. The other end is then hauled taut by hand and belayed. The sliprope must be rove so that it will not jam, or be jammed by, the bridles.

Taking off first bridle

The usual method is to take off the working bridle first; this is done by veering it, unshackling it from the buoy as soon as there is enough slack, and then heaving it in and tailing it on to the inboard end of the standing bridle after removing the securing-to-buoy shackle. When the bridle is long its weight will have to be taken off the securing-to-buoy shackle before it can be unshackled; there are different ways of doing this, a simple one being to reeve a hanger from the buoy shackle to a conveniently near link of the bridle; the hanger will then take the weight of the bight as the bridle is veered.

Taking off second bridle

The weight of the ship is transferred to the sliprope, either by belaying the sliprope and veering the remaining bridle, or by bringing the sliprope to the capstan and heaving it in while veering the bridle; the latter method is quicker and keeps the buoy steadier, and so it is more suitable in bad weather. When slack, the bridle is unshackled and hove in. The weight must not be taken on the sliprope, nor must the second bridle be removed, until orders are received from the Captain, which will be when the main engines are ready and the special sea dutymen are closed up.

To slip

The turns of the sliprope are surged and cast off the bollard or capstan, and the slip on the eye is knocked off; the rope is then run in by hand. If there is much weight on the slip when it is knocked off it will probably jump up and may injure whoever knocks it off. It is therefore always advisable to ease off the strain on the slip first; but if this is not practicable, see that everyone stands well clear.

Slipping by the stern from a buoy

In a crowded anchorage where there is little room for manoeuvring it may be necessary before slipping from a buoy to point the vessel in a direction other than that in which she is lying. This is done by reeving an additional sliprope, from the quarter fairlead, outboard of all, through the buoy shackle and then back through another quarter fairlead, and then putting the eye on a slip. The ship is then given a cast in the required direction, the head sliprope being surged as necessary and any slack in the after sliprope being taken down. The head sliprope is then slipped and run in, and, when the ship is pointing in the required direction, the after sliprope is slipped and run in.

MEASURES TO AVOID PARTING CABLE

A ship's cables should be looked after most carefully, because her safety in an anchorage depends on them. If they part and are irrecoverable a ship has no other means of securing to the sea-bed and must seek an alongside berth or go to a buoy, provided that she has sufficient cable left to do so.

Never anchor at excessive speed and never snub the cable unless there is an

emergency such as, when anchoring, to avoid, or lessen the impact on, grounding. When anchoring in deep water veer the anchor to within a few fathoms of the bottom before letting go.

When anchoring with the stream be careful to take all way off the ship before she turns athwart the stream. Ships have run out to a clench and parted cable when the ship is helplessly athwart the stream.

The parting of chain cable is mainly due to the gradual weakening of the cable as a result of the excessive strain to which it is subjected, particularly when mooring; but the brittleness caused by the battering that the cable receives when being worked is a contributory factor. A cable usually parts in one of the first six shackles which are used most. Mooring ship, however carefully carried out, is liable to strain the cable when middling with a taut moor. These strains gradually distort and weaken the links, but so long as the cable does not part this distortion is likely to be ignored. When eventually the cable parts for no apparent reason the accident is attributed to defective material or too small a cable, but in such circumstances it is doubtful whether a larger cable would have withstood the strain.

It is possible for links to become fractured when cable is lowered too fast or dropped into cable lockers or on to the bottom of a dock. Cable should always be lowered gently, using strops of sufficient strength to take the weight of the cable. Should the cable accidently be allowed to run at excessive speed, it should invariably be surveyed.

The practice of veering the mooring swivel to the bottom in a gale very much reduces the strain on the cables, particularly when at open hawse.

In vessels of fine lines such as destroyers and frigates, when shortening-in or weighing, the cable may grow under the forefoot or athwart the stem and be subjected to a bad nip. When this occurs, stop heaving in until the bows swing towards the anchor and the cable grows clear again; otherwise the links and joining shackles will be severely strained and may part.

Special attention should be paid to the condition of shackles on all occasions of weighing, to ascertain whether any sign of strain exists.

CHAPTER 10

Laying out Hawsers and Anchors, Towing, and Target Work

A man-of-war must be prepared to warp or kedge herself from one place to another, to take in tow and to be taken in tow, and to carry out target-towing duties. It is not possible to give more than the general principles in this chapter, because ships' rigs differ considerably in detail, but the seaman should be guided by the methods described, remembering that the laying-out of hawsers and anchors, towing and being towed usually have to be carried out when one's own ship or some other ship is in urgent need of assistance. Target-towing is a practical seamanship duty.

The rescue of a stranded vessel and the laying-out of heavy ground tackle to salvage her, also the many shiphandling and advanced seamanship aspects of towing at sea, are described in Volume III.

LAYING OUT HAWSERS AND ANCHORS

In addition to warping or kedging herself from one place to another, a man-of-war may lay out a hawser to hold herself temporarily in a certain position, or to assist in hauling her off, or to prevent her being driven further ashore, after she has grounded.

LAYING OUT HAWSERS

The method of laying out a hawser by boat depends upon the type of boat available, the size of hawser, the distance to which the hawser has to be taken, and the strength and direction of wind and current or tidal stream and their direction relative to the intended line of the hawser.

If the hawser is to be laid out *up* wind or stream it is best to take the entire hawser in the boat to the position at which its end is to be made fast, and then pay it out over the stern or quarter of the boat as she returns to the ship. A natural or man-made fibre hawser would be coiled down amidships, or, if there is sufficient room, in the stern-sheets; but a wire hawser, because of its weight and bulk, must be stowed where there is sufficient space and without affecting the stability of the boat. Where space is available and the stability of the boat would not be adversely affected the wire should be embarked reeled upon its reel, which must be securely lashed in position. If the stability of the boat would be affected by having such a weight concentrated in one place, the hawser should be coiled down in the boat, the size of the coils being as large as possible.

All hawsers should be paid out under control over the stern or quarter. A

2½-in. or larger wire hawser should be controlled by a chain check stopper secured to the after sling plate or other suitable anchorage; a hawser paid out from a reel can also be controlled by the band brake. The speed of the boat should be limited so that the hawser remains under control. A portable metal or wooden scotsman should be placed to prevent the hawser scoring the boat at the point where it leads over the stern or quarter. When the hawser is too bulky or heavy to be carried in the boat it can be hauled out to the required position on a messenger previously laid out by the boat.

If the hawser is to be laid out *down* wind or stream the end is passed from the ship to the boat and secured in the bows of the boat; a few fathoms are coiled down in the boat, and the bight leading from the stern or quarter is held by a cordage or chain stopper secured to the after sling plate or other suitable anchorage. The boat then proceeds to the required position and the hawser is paid out from the ship. When the boat arrives at the position the end of the hawser is unstopped from the bows and passed to the securing position, the slack of the hawser in the boat being lighted forward at the same time. After the hawser has been made fast, the remainder of the slack is passed outboard and the bight is eased out on the cordage or chain stopper until it is clear.

If a cordage hawser is to be laid out *across* wind or stream a few fathoms of it should be coiled down forward, and a further length, equal to about half the distance to be covered, should be coiled down aft with its bight stoppered. The boat then steers to the required position, making allowance for leeway, while the bight is paid out from the ship; and when she has covered well over half the distance she pays out the length coiled down aft as she covers the remaining distance. If the position to which the hawser is to be laid out is some distance away a second boat may be used to under-run and support the weight; the bight should be hung from the stern or quarter by a sliprope and not laid across the boat, and the boat should head up wind or stream at a speed which will advantageously reduce the catenary in the bight of the hawser.

If a wire hawser is to be laid out *across* wind or stream it is best to take it in the boat reeled up on its reel, and then secure the end at the required position and pay it out over the stern or quarter of the boat while returning to the ship. When paying out the hawser, sufficient allowance for drift or leeway must always be made in the course steered, because the boat will be unable to make good any leeway while dragging the heavy bight of the hawser against wind or stream. A second boat may be used to support the bight and to keep it up wind or stream.

LAYING OUT ANCHORS

A ship can lay out one of her bower anchors when she wishes to move bodily in a certain direction, or kedge from one position to another, or haul herself off after she has grounded, if her largest boat can support the weight of the anchor. In addition, destroyers and frigates have a 300-lb Danforth anchor (killick) for laying out as a light anchor to point ship or to prevent the stern from swinging towards an obstruction, for example. As in the laying-out of hawsers, the method employed depends upon the size of the anchor, the size of the boat or boats available, and the depth of water in which the anchor is to be laid. Two typical methods are described here as a general guide.

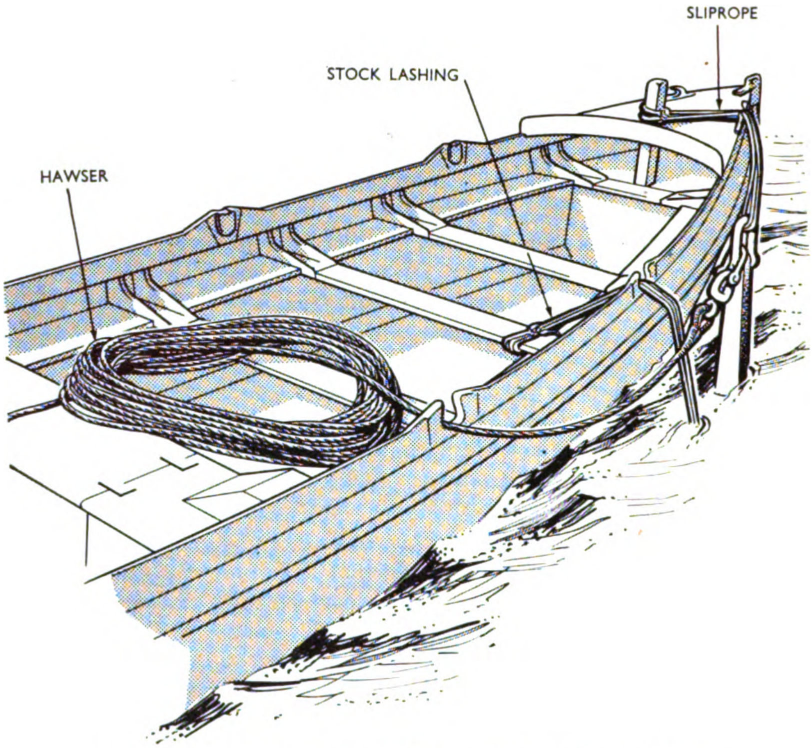


FIG. 10–1. Motor whaler taking away killick and hawser

To lay out a killick

The boat most commonly used to lay out this light anchor is the motor whaler. The anchor is slung from a sliprope or stout lashing, which is secured to the towing bollard and led through one of the bow fairleads. The anchor should be prevented from damaging the forward planking as the boat steams through the water by bowsing the stock aft with a temporary lashing (fig. 10–1), which also stops any tendency for the anchor to spin. The swivel-piece is first shackled to the ring of the anchor, then the hawser is shackled to the swivel-piece, led outboard and aft, and lightly stopped. Using old canvas to protect the boat and its fittings, the remainder of the hawser is coiled down in large coils forward of the engine casing. The boat is first brought under a suitable davit and the anchor hoisted out and lowered to the boat, the hawser being kept slack from inboard. The flukes should now be tripped so that they are away from the boat and the stock lashing passed. When the ring of the anchor is level with the appropriate fairlead the sliprope is rove and secured to the towing bollard, the anchor is lowered until its weight is taken on the sliprope, and the davit purchase or whip cast off. The hawser is then passed down to the boat and coiled down, its eye secured to the after sling plate, and the stock lashing hove taut through the foremost rowlock and secured round the thwart.

When proceeding to the position where the anchor is to be laid out, one member of the crew should remain forward to tend the sliprope and stock lashing and the remainder should be aft to trim the boat. When the position is reached the stock lashing is removed, the engine taken out of gear, the light stops supporting the bight of the hawser outboard cast off, and more than sufficient wire for the depth of water paid out hand over hand. The bight is then taken aft and held by a cordage or chain stopper. The anchor is then slipped and the boat heads back to the ship, paying out the hawser.

A variation of this method is to retain the bulk of the hawser in the ship and for the boat to hang the anchor with the hawser secured as before, securing the bight of the hawser aft with a cordage or chain stopper. The ship pays out the hawser as the boat steams to the position in which the anchor is to be laid out. When the boat reaches the position the stopper is cast off and at the same time the anchor is slipped.

The coxswain must always keep his boat trimmed, and he must adjust his course to allow for leeway when the wind or stream is athwart the line of travel.

A buoy-rope, strong enough to weigh the anchor and of a length of at least twice the depth of the water at high water, must be used. It is rove through a block secured by a suitable strop to the crown of the anchor, and both ends are then bent to the anchor buoy. The buoy and buoy-rope should be streamed just before the anchor is slipped.

To weigh the killick the buoy and both ends of the buoy-rope are recovered into the bows of the boat. One end of the buoy-rope is placed in one fairlead and secured round the towing bollard and the other is placed in the opposite fairlead and hauled on by the boat's crew. To break the anchor out of the bottom it may be necessary to secure both ends of the buoy-rope to the towing bollard and steam the boat in a direction away from the ship until the anchor is felt to break out. The anchor can then be recovered and secured, and the hawser either coiled down in the boat or hove in by the ship.

To lay out a bower anchor

The boats which can be used to lay out a bower anchor, and the freeboard when the anchor is slung, are given in the table below.

Class of ship	Anchor weight (cwt)	Type of boat	Freeboard (in.)	Remarks
Carrier				
Ark Royal ..	190	45 ft M.L.	36	——
Hermes	160	36 ft M.P.	20	——
Cruiser				
Tiger	95	36 ft M.P.	22	——
Destroyer				
Devonshire ..	52	27 ft M.W.	9½	½ in. below top of keel box
Duchess ..	45	27 ft W.	12	2 in. below top of keel box
Frigate				
Type 14 ..	16	27 ft M.W.	15	6 in. below top of keel box

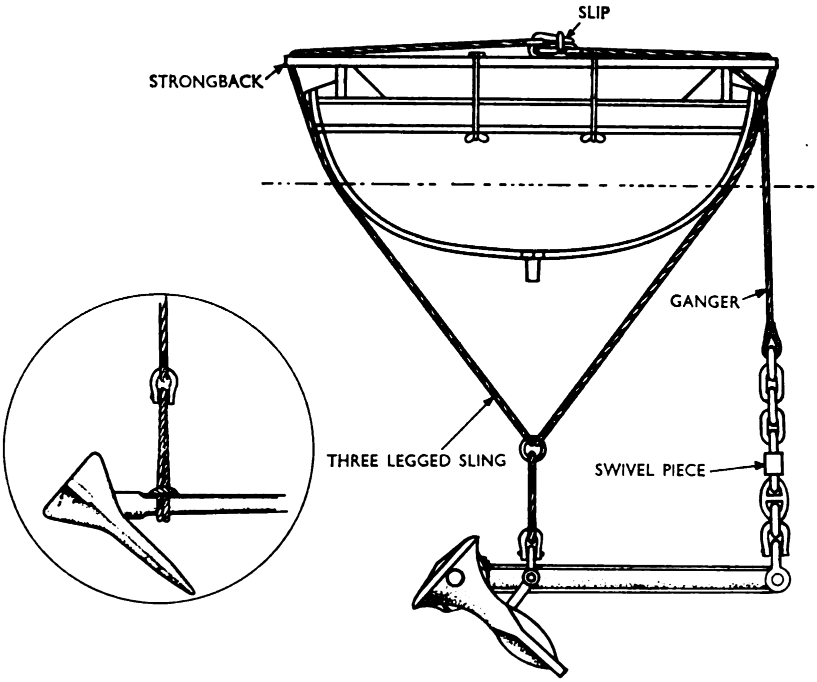


FIG. 10–2. Bower anchor slung beneath a boat

Being much heavier than the killick, the bower anchor must be slung below the boat on a special three-legged sling fitted with a slip (fig. 10–2). To overcome the crushing effect of the sling on the boat, an oak strongback[1] is placed amidships and bolted in position. The span of the anchor sling is then rove under the boat, over the strongback, and secured by means of its slip; the leg of the sling is stopped to the gunwale. The boat is then brought round and made fast abaft the position from which the anchor is to be lowered.

The cable of the anchor which is to be laid out is broken abaft the swivel-piece and a special pendant of wire rope, called a *ganger*, is shackled to the swivel-piece; the other end is shackled to the mooring pendant and the latter then brought to the capstan. The weight of the anchor is now taken on the mooring pendant, the screw slip eased and knocked off, and the anchor lowered to the water. The purpose of the ganger is to provide a pendant of sufficient length to reach from the ring of the anchor to the gunwale of the boat when the anchor is slung beneath her.

When the anchor is awash the boat is hauled forward and the leg of the sling shackled either to the gravity band of the anchor or to a grommet strop of sufficient strength if no gravity band is fitted; at the same time a buoy-rope rove through a block is either bent to the shank or shackled to the gravity band if one is fitted. The anchor is then slowly lowered until the boat gradually takes

[1] Strongbacks are provided to ships on request if the largest boat is capable of supporting a bower anchor.

the weight, care being taken to keep the slip of the sling amidships, for which the use of a small jigger may be necessary. The ganger is then securely stopped to the gunwale with a stout hanger, and the mooring pendant unshackled and recovered inboard.

The hawser to be used with the anchor is usually the towing hawser. The methods of embarking and then laying it out depend on whether a wire or man-made cordage hawser is used. There is an advantage in using a wire hawser in deeper waters, because the weight of the wire helps to maintain the pull on the anchor nearer horizontal than when a Nylon hawser is used.

Using a wire hawser. The hawser is coiled down in another boat. Its first eye is securely stopped to a suitable anchorage (for example, the after sling plate) and the hawser is coiled down with the coils reaching forward and aft and close to her sides, and each coil is secured by stops to each bow and quarter; in addition each coil is secured to a strong fitting (for example, the forward ring-bolt) by a long hanger rove with a complete turn round each bight of the hawser. These hangers are used to ease out the bight of each coil.

The last length of hawser, which must be greater than the depth of water in which the anchor is to be laid, is passed round the outside of the boat, the turns being hung by stout strands secured inside the boat; the end is passed to the boat from which the anchor is slung, and then shackled to the ganger.

The eventual surging of the hawser from the boat is controlled by a chain check stopper, the position of which differs in each type of boat. The seaman must remember that this is an extempore operation and he must make do with the existing strong fittings in the boat: for example, the standing part of the stopper should be shackled to the after sling plate and the hauling part controlled by a jigger, the standing block of which should be secured well forward. A scotsman must be placed to prevent damage to the boat as the hawser is paid out.

The boat with the hawser is now towed by the boat with the anchor to the position in which the anchor is to be let go. A sounding is taken to check the depth of water and when both boats are in position the chain check stopper is bowsed down, the crew stand clear of the bights of the hawser, and the stops holding the outer turns of the hawser are cut. When these turns are seen to fall clear of the boat the anchor buoy is streamed from the other boat and the anchor is let go by knocking off the slip of the sling.

As heavy wire hawsers are dangerous if allowed to take charge, every precaution must be taken to ensure that the hawser is under control while being surged from the boat. Those manning the stopper and easing out the hangers must be seamen of experience. Much can be done towards perfect control by using a speed of return to the ship which is consistent with the efficiency of the seamen handling the hawser. As the boat returns to the ship, or to wherever the end of the hawser is required, the hawser is paid out by cutting the stops on each coil, easing out the bight of each coil by its long hanger and controlling the speed of surging by the chain stopper.

With some boats it may be necessary to fake the hawser down in the boat instead of coiling it; when this is so the same rules apply with regard to stopping each fake to the bows and quarters, securing each bight with its own hanger, and controlling the speed of surging by the stopper.

Using a Nylon hawser. The hawser is faked down in another boat. If it is coiled down there is a risk of kinking as each coil is eased out, and such kinking could be of a permanent nature, making the rope unfit for further use. To the bight of each fake is secured a long hanger which in turn is hitched to some convenient strong-point forward in the boat. No check stopper can be used with Nylon cordage, because the friction would be sufficient to fuse and fray the outer filaments, resulting in a marked reduction of the strength of the hawser. Therefore each hanger controls that length of hawser comprising one complete fake and, when eased until the hanger of the next fake has the strain, is cast overboard and remains secured to the hawser. Since the point of control is right forward the hawser must be paid out through a strong and wide fairlead aft; otherwise the hanger might sweep to one side or the other, trapping men between the bight of the fake and the gunwale of the boat, or the bight might be jammed as it enters the fairlead.

The speed of the boat as it is towed to where the end of the hawser is required must be consistent with the efficiency of the seamen manning each hanger, and the hawser must be well protected from chafe as it is eased out over the stern.

The method of securing the hawser to the ganger, the turns stopped round the outside of the boat, and the operation of letting go the anchor are the same as for a wire hawser.

To weigh a bower anchor

If the anchor is sufficiently light and the type of boat used is fitted with an adequate fairlead and a conveniently positioned strong-point, it can be weighed in the boat by the buoy-rope, or by the hawser using two luffs alternately, each being shackled to the strong-point. To break the anchor out of the bottom it may be necessary to use luff upon luff or to steam the boat in a direction away from the ship until the anchor is felt to break out.

If, as is often the case, the anchor is too heavy to be weighed in the boat, the buoyancy of the boat in tidal waters can be used to break it out of the bottom on a rising tide. To do this the boat is fitted with its strongback and positioned over the anchor at low water; the two parts of the buoy-rope (if of sufficient strength) are hauled taut over the strongback and secured together by bulldog grips. As the tide rises the buoyancy of the boat should then break out the anchor, and the boat with the anchor slung beneath it can then be towed to the ship. An axe, or wire-cutters, should be ready at hand to cut the buoy-rope if it appears that the buoyancy of the boat is insufficient. When a power boat is used for this method of weighing the exhaust should, of course, be plugged.

If the buoy-rope is not strong enough to break out the anchor, the boat must be fitted with a sling and a diver be sent down to shackle it to a leg of the sling already on the anchor; the total length of the two slings must be adjusted to the depth of the water at low tide.

Conclusion

As with any extempore seamanship, there are three basic requirements—experience, common sense and a seaman's eye for detail. Men-of-war are seldom

required to lay out hawsers and anchors, yet the safety of your ship may some day rest entirely upon the rapid and efficient way in which this gear is laid out; the operation should therefore be carried out as an exercise at least once in every commission.

TOWING AND TAKING IN TOW

Towing can be defined as either receiving motive assistance from, or rendering it to, another vessel; the assistance can be classed as *emergency*, when one ship takes another in tow on the high seas, using the gear available in both ships; or *planned*, when the towed ship is prepared for towing from one port to another.

A man-of-war should always be prepared at short notice to take another ship in tow or to be taken in tow herself, either from forward or aft. All men-of-war are equipped for towing or being taken in tow and this section describes the various rigs and methods used within the Fleet for the preparation, passing and securing of towing gear, using both wire rope and man-made fibre cordage towing hawsers; also the preparations required before a 'dumb' (unmanned) or 'live' (manned) vessel can be moved from one port to another, and some hints and precautions when being moved by tug.

The seaman must realise that this subject requires a sound knowledge of the gear and a high degree of skill in its use.

TOWING GEAR AND ARRANGEMENTS

Towing hawsers

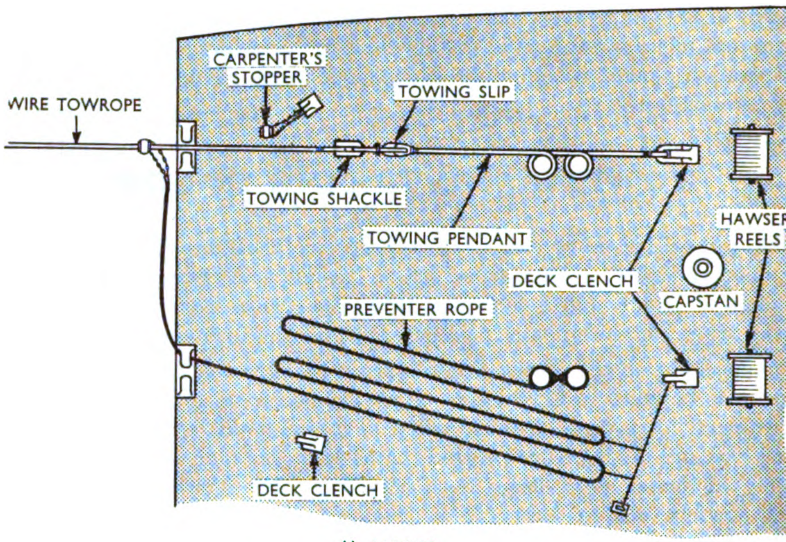
There are two types of hawser supplied to men-of-war for the purpose of *emergency* towing—wire rope hawsers and man-made fibre cordage hawsers. All ships will eventually be supplied with man-made (Nylon) fibre hawsers, but at present (1964) wire rope hawsers are still used in the Fleet.

Men-of-war are usually provided with two towing hawsers of F.S.W.R., one usually smaller than the other and the size of each depending upon the size of the ship. As a ship usually tows, or is towed, by one hawser only, her larger hawser is usually stowed on a reel forward, and the smaller hawser on a reel aft. If the towing hawser is Nylon, only one is provided.

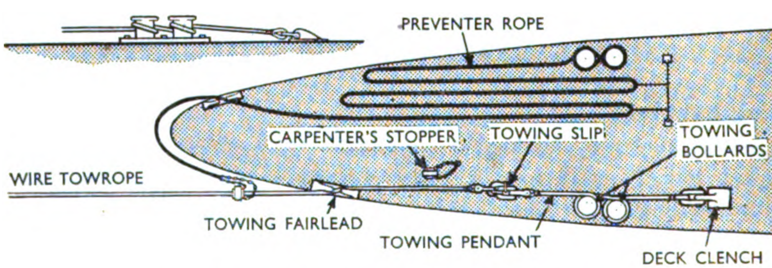
A wire rope is light for its strength, but not elastic, therefore it is usual to join the towrope to the cable of the ship being towed, which then veers on power a shackle or more of her cable so that its weight will act as a spring on the towrope and absorb any sudden heavy stresses.

A Nylon towrope, because of its great elasticity and ability to absorb shock-loading, needs no other spring; therefore the cable to which it is secured is veered until the Nylon is just clear of the bows so that the cable takes the chafe; any sudden or heavy strain upon the towrope is absorbed by the Nylon as it stretches (approximately 30 per cent of its length when subjected to a strain within its safe working load).

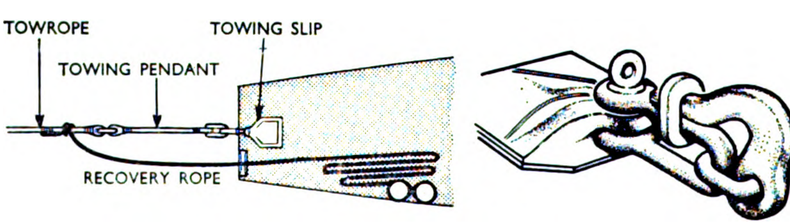
A ship may be towed with the towrope led through a bower anchor hawsepipe or stem hawsepipe or foremost fairlead or the bullring. A swivel-piece may be



(i) CARRIER



(ii) CRUISER (INSET: METHOD OF SECURING TOWING PENDANT)



(iii) DESTROYER/FRIGATE (INSET: TOWING SLIP)

FIG. 10–3. Towing arrangements in men-of-war

inserted between the cable and a wire hawser, but not between the cable and a Nylon hawser.

When the towrope is a composite one, i.e. a wire rope hawser and chain cable, the correct ratio between the length of hawser and the length of cable must be established. This is discussed in Volume III.

Harbour tugs usually use cable-laid manila or man-made fibre hawsers as towropes; these make good towropes, because they are far more elastic and more easily handled than wire hawsers. Cable-laid manila cordage does not tend to lay up or unlay when under strain and is more flexible and water-resistant than hawser-laid manila. Terylene and Nylon cordage have great shock-absorption qualities and are most suitable for close control work within the confined waters of rivers, ports and harbours.

Towing arrangements

The tow should be capable of being slipped at a moment's notice in emergency and provision for this is made in the towing ship by securing the towrope on a special towing slip.

The arrangements in men-of-war for towing aft are shown in fig. 10–3. In frigates and some destroyers the towrope is shackled to a short pendant which is secured to a hinged slip fitted at the stern and on the centre line; as this slip will not take the eye of a large hawser a special towing shackle, long in the clear, must be used. The towing pendant is introduced because it is difficult and often dangerous to attempt to secure the end of a heavy towrope directly to the towing slip. With the towing pendant it is possible to make the connection on deck.

Aircraft carriers and other large ships, cruisers and modern destroyers tow from a special set of after bollards which are much stronger than the bollards for berthing hawsers and other purposes. The anchorage for the towing pendant is a special deck clench fitted before the bollards. The size of the towing pendant is the same as that of the largest wire hawser or, if the hawser is Nylon, of comparable strength; and the towrope is secured to the pendant by a towing shackle and towing slip.

Since there is no means of freshening the nip of the towrope in the fairlead, or shortening or lengthening the tow, the fairleads and any other bearing surface must be well and carefully packed with wood or other material to lessen the chafe, and the towrope should be well served with rounding where it passes through the fairlead or where it bears against any surface. If the tow is of a long duration consideration should be given to transporting a half-shackle of cable aft where it can be inserted between the towrope and the towing pendant; this will reduce the possibility of the composite towrope parting through chafe. Normally the length of tow is adjusted in the towed ship, but this can be done in the towing ship by shackling another hawser to the towrope and belaying it to bollards before the towing bollards; if this is done in the towing ship, however, the tow cannot be slipped at a moment's notice in emergency. If the tow has to be shortened by the towing ship the towing hawser itself must be taken to the towing bollards and then belayed to other bollards, and again it could not be slipped suddenly in emergency.

Where the towrope is of man-made fibre cordage it should not itself be

belayed round bollards, as this would cause fusing of the outer filaments as the towrope tightens and then slackens under load. Such a towrope should be secured to a wire towing pendant with a slip and shackle, and the towing pendant secured to the deck clench and belayed round the towing bollards in the normal way. The same precautions should be taken to reduce chafe as the towrope passes through the fairlead, or where it comes in contact with any bearing surface.

PREPARATIONS FOR TOWING

The preparations for towing or being taken in tow vary with the type and size of the ship and the layout of her forecastle, quarterdeck and upper deck. The type and size of the hawser to be handled also has a bearing on the extent of the preparations, because a heavy hawser must first be unreeled and then faked or ranged in such a manner that it will be under full control when paid out. As examples, typical arrangements in a cruiser and a modern frigate for being taken in tow and for towing are described below and illustrated in figs. 10–4 and 10–5.

Preparations in a cruiser to be towed

Whenever practicable the ship to be towed should provide the hawsers and messengers, because when the tow is slipped it is far easier for her to recover the tow with her cable gear. i.e. capstan and cable holders. But the towing ship should also be prepared to provide the hawsers and messengers.

The port cable is broken abaft the swivel-piece and the spare swivel-piece shackled to its end. The Blake slip is put on the cable as a preventer to stop the cable from dropping off the cable holder snugs and running back down the navel pipe, or being dragged aft as the last bight of the hawser is paid out.

The first end of the towing hawser is taken from the reel and shackled to the swivel-piece. The bight is then led aft along the port catwalk, where a wire paying-out rope is shackled on to it with a bow shackle, the bolt of the shackle passing through the eye of the paying-out rope; otherwise it may be unscrewed by the movement of the hawser as it is paid out. The remainder of the hawser is faked down on the port side and each after bight is securely stopped to an athwartship jackstay. The last end of the hawser is then unrove from the reel, taken forward, placed abreast the port fairlead, and a towing shackle shackled to it and stopped securely to its eye. One or more chain check stoppers should be conveniently placed forward to control the hawser as it is paid out to the towing ship.

A manila (or Nylon) and a coir hawser are provided as messengers. The end of the manila is passed outboard through the starboard fairlead, in through the port fairlead, hitched securely with a rolling hitch to the towing hawser just below the splice, and the eye of the hawser then securely stopped to the manila; which allows for a fair lead as the join is hove inboard on the towing ship. The remainder of the manila hawser is faked down just abaft the starboard fairlead, and the coir hawser abaft the manila. The manila and coir hawsers are then bent together, using a carrick bend. The last end of the coir hawser is passed

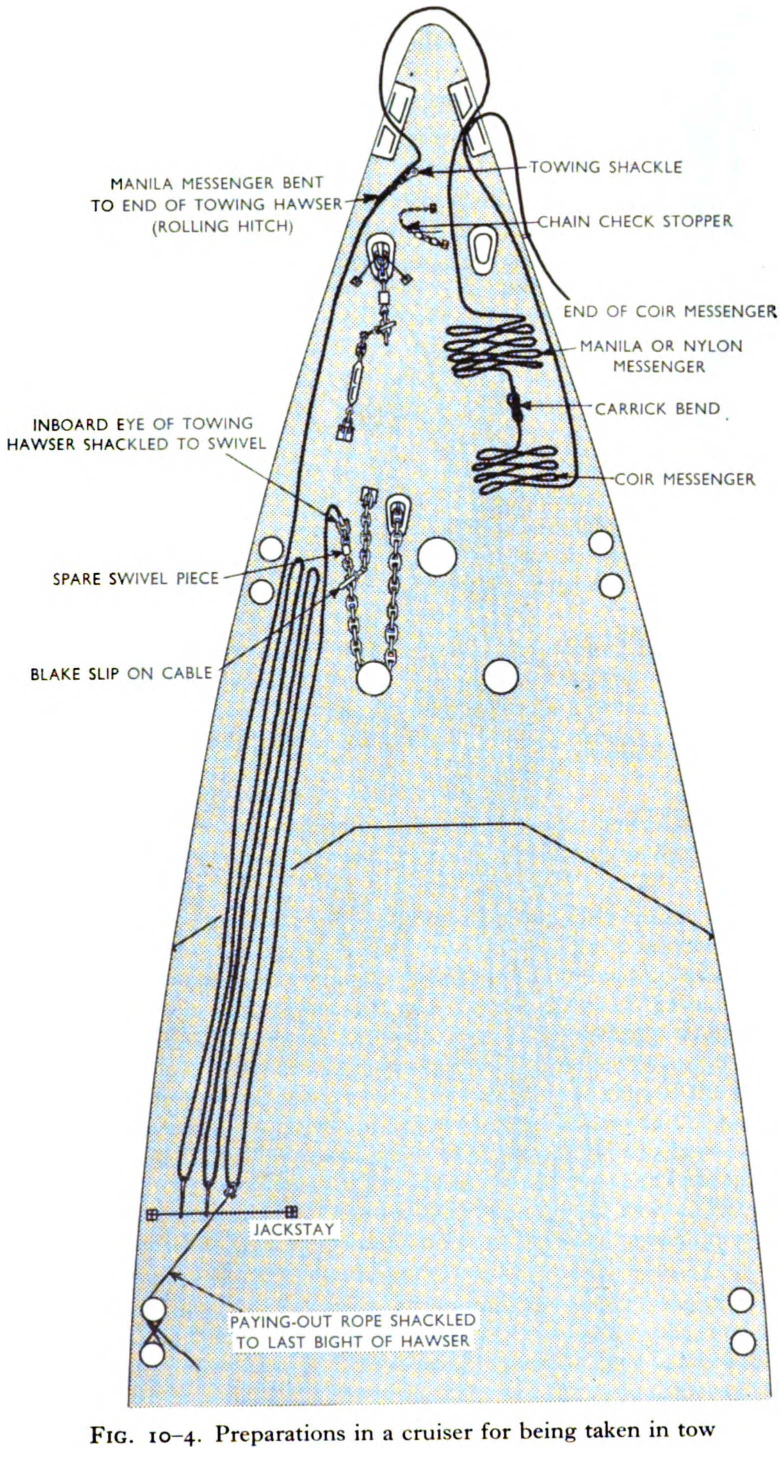


FIG. 10–4. Preparations in a cruiser for being taken in tow

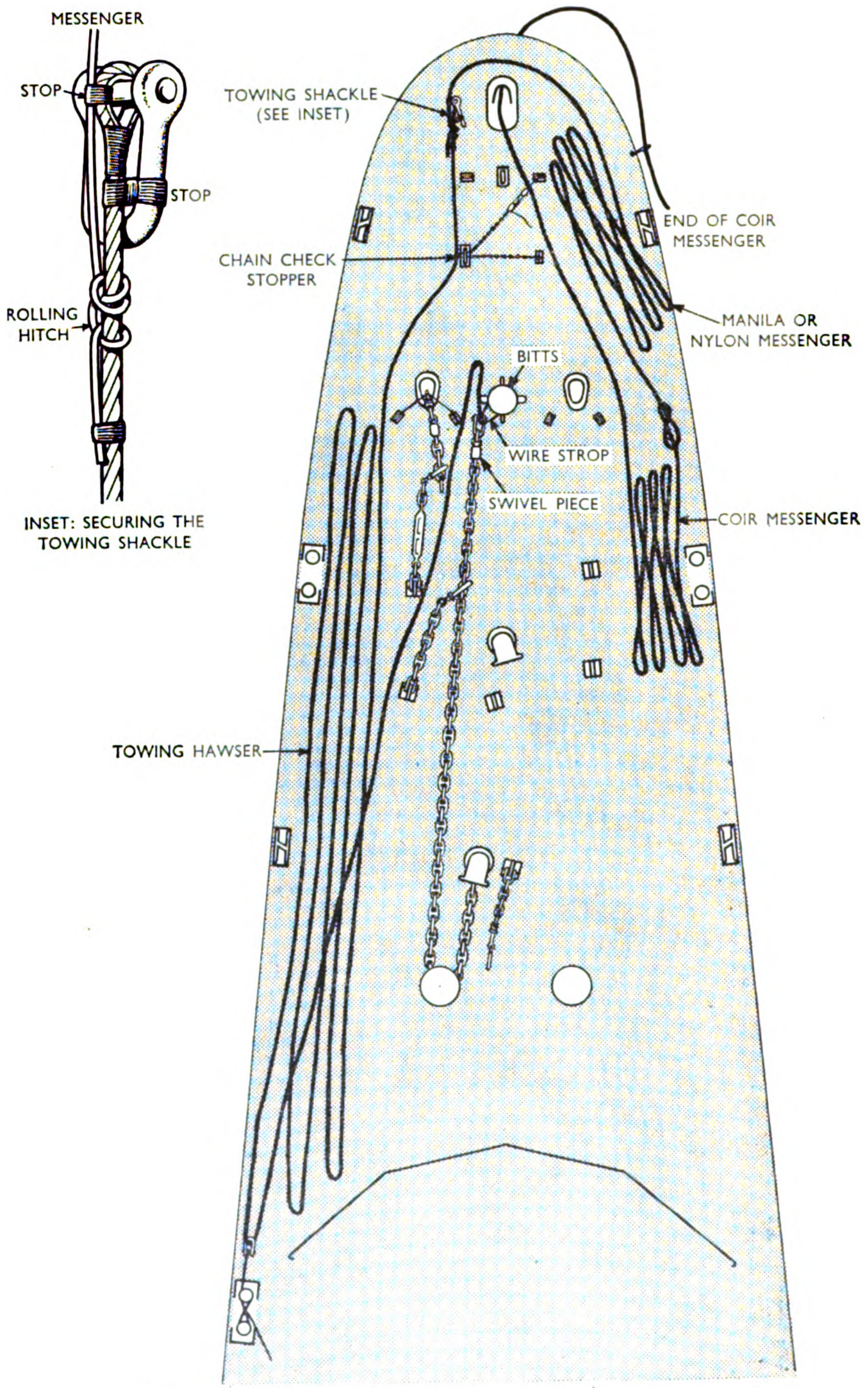


FIG. 10–5. Preparations in a frigate for being taken in tow

outboard through the starboard fairlead, back inboard and lightly stopped in position a few fathoms from its end. The ship is now ready to pass the gear.

Preparations in a cruiser which is towing

The preparations in the towing ship are not nearly so extensive as those in the ship to be towed, unless she has to provide the hawsers.

The towing pendant is shackled to its deck clench and belayed to the bollards with one turn round each bollard (fig. 10–3), and the other end is led aft and to it is shackled the towing slip. A towing shackle is provided in case the other ship does not send one over with her hawser. A Carpenter's stopper is shackled to the deck clench before the towing fairlead, and shot mats are provided under the stopper and the towing slip. Wood packing for the fairlead and rounding for serving the hawser should also be provided. A second Carpenter's stopper and a recovery wire should be placed aft, the purpose of which will be described later.

If the tow is of long duration and it is decided to insert a half-shackle of cable, it would be shackled to the towing slip, with the rest of the cable ranged on deck, and a swivel-piece may be shackled to its other end ready to be shackled to the towing hawser. A wire messenger, used both as an easing-out wire and a recovery wire, should be secured to the cable at the third link from its outboard end with a strong grommet strop and shackle.

If the tow is undertaken in fairly shallow water, and if it may have to be slipped in an emergency and recovered later at short notice, provision should be made to buoy the end of the towing hawser; a cordage or wire hawser of suitable size and length bent to an oil drum should suffice for this purpose.

Preparations in a frigate to be towed (fig. 10–5)

As with any man-of-war, the one to be towed should normally provide the hawsers and messengers; but the towing ship should always be ready to provide them.

The cable is prepared in the same way as described for a cruiser, except that the end of the cable must be stopped to the bitts to hold it forward when the last bight of the towing hawser is being paid out. The first end of the towing hawser is shackled to the swivel-piece and the remainder of the hawser faked down on one side of the forecastle, with each bight securely stopped to an athwartship jackstay. If the towing hawser is of wire rope a paying-out rope is shackled to the bight of the hawser which is next to the cable. If the hawser is of Nylon the paying-out rope would be of cordage hitched to the hawser, or the hawser would be paid out by hand. The last end of the hawser is then unrove from the reel, taken forward and placed abreast the stem hawsepipe, and a towing shackle is shackled to it and stopped securely to its eye. With a wire hawser a chain check stopper must be placed abaft the stem hawsepipe to control the hawser as it is paid out to the towing ship.

A manila (or Nylon) and a coir hawser are provided as messengers. The end of the manila is hitched to the towing hawser just below the splice and the eye of the hawser then stopped to it. The remainder of the manila is faked down on the other side of the forecastle abreast the stem hawsepipe, and the coir hawser abaft it. The manila and coir hawsers are then bent together, using a carrick bend.

The last end of the coir hawser is passed outboard through the stem hawse-pipe, back inboard and lightly stopped in position a few fathoms from its end, and the ship is now ready to pass the gear. In ships provided with a Nylon towing hawser only one messenger need be used, and this would be of Nylon and of a much smaller size than the hawser itself.

Preparations in a frigate which is towing

The wire towing pendant is placed on the towing slip (fig. 10-3) and its other end laid back inboard. A messenger of wire or cordage is provided as an easing-out or recovery rope if the messenger provided by the towed ship is not used for this purpose. If the towing hawser is of Nylon the messenger must be of Nylon. If the towing hawser is wire, a Carpenter's stopper must be provided. A towing shackle is also provided in case the other ship does not send one over with the hawser.

For the reasons previously stated (page 361) the practice of placing the towing shackle, which is shackled to the eye of the towing hawser, directly on the towing slip is dangerous and should, therefore, not be attempted.

TAKING IN TOW

Establishing contact

Contact with the ship to be towed may be established by a gun-line, helicopter, or boat towing the coir hawser.

If the ship to be towed is drifting fast she may stream a coir or man-made fibre hawser bent to a small buoy or float so that it lies to windward of her and can be grappled by the towing ship; or the towing ship may tow a buoy on a coir or man-made fibre hawser across the other ship's bow or quarter for her to grapple as she drifts across it. This problem of contact between two ships is discussed in greater detail in Volume III.

Passing and securing the tow

In the towed ship. The messengers, and then the towing hawser—under the control of a chain check stopper and paying-out rope if the hawser is of wire—are paid out; the towing shackle may have to be guided clear of obstructions by handspike. The paying-out rope may then be unshackled and the cable holder connected: and, when the towing ship reports that the tow is secured, the Blake slip is knocked off and cable is veered until the hawser is clear of the towing lead if it is Nylon; or veered an amount depending on the depth of water, weather, speed of tow and nature of tow if the hawser is wire. The brake is then applied 'brake to brake', the riding slip or compressor put on as a preventer, and the cable holder disconnected.

In the towing ship. The messengers are run in, then brought to the capstan and hove in until there is enough towing hawser on deck to make the connection; the hawser is then held by a Carpenter's stopper if it is wire, or by a Nylon stopper if it is Nylon.

The tow is now joined by putting the towing shackle over the towing slip in ships with clench and bollard anchorage; or by shackling the towing hawser

to the outer end of the towing pendant with the towing shackle in ships with stern towing slips; or by shackling the towing hawser to the end of the half-shackle of chain cable (or swivel-piece, if inserted).

It is now necessary to take the weight of the towing hawser so that the stopper may be taken off and the hawser eased out until the strain is taken by the slip; how this may be done is discussed in the next paragraph.

A signal is then sent to the towed ship that the tow has been secured.

Easing-out, preventer and recovery ropes

An easing-out rope is used to take the weight of the towing hawser so that the stopper may be taken off and the hawser eased out until the weight is taken by the towing slip.

A preventer is used only in the clench and bollard rig, whether the towed or towing ship provides the gear, so that the hawser may be recovered if it parts in or before the fairlead (see fig. 10-3).

A recovery rope must be used in the stern slip rig to haul the towing hawser on to the deck so that it can be unshackled from the towing pendant; it is used in the bollard and clench rig to take the weight of the hawser before the slip is knocked off.

Clench and bollard rig. If the hawser is of Nylon, the Nylon messenger can be used as easing-out, preventer and recovery rope. The hawser is stoppered on deck, then the messenger is taken off and hitched again with a rolling hitch, dogged and stopped, outside the fairlead. The messenger then takes the weight, the stopper is taken off and the hawser is eased out until the weight is taken on the towing slip. The messenger is then led through another fairlead, faked down with the forward bights stopped to a jackstay, and belayed round bollards as a preventer. It is used as a recovery rope when slipping the tow.

If the hawser is of wire, a Carpenter's stopper shackled to a wire and put on abaft the fairlead is used as an easing-out, preventer and recovery rope in exactly the same way.

Stern slip rig. If the hawser is of Nylon or wire, the messenger can be used as the easing-out and recovery rope.

SLIPPING AND RECOVERING THE TOW IN MEN-OF-WAR

Slipping. The method of slipping depends on the rig. In the stern slip rig, the hawser, whether Nylon or wire, is hove in by the messenger (recovery rope) until the hawser is on deck, where it is stoppered, unshackled from the towing pendant and paid back by the messenger.

In the clench and bollard rig the preventer is first taken off (i.e. Carpenter's stopper on a wire hawser and messenger on a Nylon). The messenger is then secured below the splice of the hawser and hove in to take the weight, the hawser is then stoppered, the slip is knocked off, the weight taken off the stopper and the hawser paid back by the messenger.

Recovery. In the towed ship a wire rope or cordage messenger of suitable size is led from either the bow fairlead, stem hawsepipe or bullring as far aft

along the forecastle as possible, where it is rove through a leading block and then taken forward to the capstan. Just before the tow is slipped it is shortened in by heaving in on the cable holder and recovering the length of cable paid out. When the eye of the towing hawser is inboard, a Carpenter's stopper (if the hawser is of wire) or a cordage stopper (if the hawser is of Nylon) is put on the hawser and, after the cable has been unshackled, the messenger is shackled to the eye of the hawser. When the tow is slipped from the towing ship the Carpenter's stopper, or cordage stopper, is cast off and the towing hawser hove in on the messenger by the capstan until the eye reaches the leading block. The stopper is then put on the hawser and its eye securely stopped; all hands then man the hawser, the stopper is cast off and the hawser is first walked in and then run in with the towing messengers. If the weight of the bight of the hawser is too heavy for the hands available another fleet must be hove in by the messenger. It may be possible to run in a Nylon hawser by hand.

It is impracticable to stow a wire hawser on its reel as it is hove in, because this would take too long; it must, therefore, be ranged on deck in a similar manner to that in which it was ranged for paying out, and then be stowed later. Care should be taken to wash it with fresh water and to lubricate it as it is stowed on its reel. A Nylon hawser should be carefully faked down on deck, kept free of sharp bends or kinking, and allowed to dry and regain its proper length and size before being reeled up. The time required depends on the amount of strain to which it has been subjected and is unlikely to exceed two hours. Failure to do this may damage the reel, and perhaps the hawser.

Other methods of securing the towrope in ships

Here are described some other methods which may be adopted for securing the towrope in ships towing or being towed.

For prearranged tows some seamen prefer to tow by a single towrope shackled to a bridle made from the two bower cables of the towed ship. If the towed ship can be steered in the wake of the towing ship the towing stresses will be divided between the two legs of the bridle; but if, as often happens, the towed ship rides at a steady angle of sheer to one side or the other of the towing ship's wake, one leg of the bridle will take most of the stress. A short bridle is not recommended, because one leg or the other will be subjected to an unfair stress or a bad nip if the towed ship yaws or takes a sheer to one side. Correcting a sheer by shortening one leg of the bridle, as is sometimes done in harbour towing, is also not recommended, because that leg will then be subjected to very heavy stresses and probably a bad nip.

Except for emergency tows or tows of short duration, it is better to lead the cable through the towed ship's hawsepipe (when she is not a man-of-war) than through her bow fairlead, because with the towrope in its normal catenary the fairlead is liable to subject the cable to a bad nip. Leading the cable through the bower hawsepipe, however, entails the removal and stowage of the anchor. For prearranged tows this is a simple matter, but for emergency tows it will probably entail jettisoning the anchor, and the decision whether to do this or risk the bad nip in the fairlead must depend upon the circumstances of the tow.

In merchant ships fitted with a guillotine and in coastal minesweepers the towing pull is taken by the brake of the windlass, and the guillotine is used as a preventer.

If the cable holders of a man-of-war are damaged she should be towed from her capstan if it is fitted to take cable. If a ship's windlass is damaged she should be towed on a bridle consisting of two legs of her chain cable; the outboard ends of the legs should be joined by a towing shackle or an anchor shackle, and the inboard ends secured to the forecastle bollards on each side by wire rope pendants or bollard strops.

If a ship has to be towed stern first it is best to tow her by a chain bridle with the legs secured to the quarter bollards by wire rope pendants or bollard strops.

For an emergency tow of short duration, such as towing a burning ship clear of a harbour, it is best to use a hurricane or spring hawser, or the largest berthing hawser available, and to secure it to the towed ship by placing its eye over the flukes of one of her bower anchors, or over one lip of the forward fairleads.

If a towing hawser is belayed to bollards it is best to use two pairs of bollards on the same side of the ship. A chain check stopper should be rove on to the towing side of the leading pair of bollards, and a bollard strop with a Carpenter's stopper attached should be placed over the leading bollard of the backing-up pair. The hawser is belayed by taking a round turn round each bollard, and then well-racked figure-of-eight turns round the backing-up pair of bollards. With this arrangement the towing stresses are fairly divided between each pair of bollards, and the hawser will be completely under control when rendering it to freshen the nip or paying it out to lengthen or slip the tow.

If only one pair of bollards is available, the bollard strop with the Carpenter's stopper should be placed over the bollard nearest the source of strain, and the chain check stopper should be rove on the towing side of the Carpenter's stopper. The hawser should be belayed by taking a round turn round the bollard nearest the source of strain, then two round turns round the other bollard, and finally well-racked figure-of-eight turns round both bollards. To render or pay out the hawser the Carpenter's stopper is put on, the figure-of-eight turns are taken off, and an extra round turn is taken round the bollard farthest from the source of strain. The Carpenter's stopper is then taken off, and, with the help of the chain check stopper, the hawser may be rendered or paid out under perfect control.

In an emergency tow, if the cable gear of the ship to be towed is in working order it is better that she should provide the cable and hawsers for the towrope and adjust the towrope to the required length, because the forecastle of a ship is better suited and equipped than a quarterdeck or poop for handling and working the heavy towing gear. It is quite likely, however, that owing to damage or some other trouble the ship to be towed is unable to work her cable gear, and towing ships should always be prepared to provide the necessary hawsers and length of cable, and to adjust the towrope to the required length. In times of national emergency it is common practice in cruisers and destroyers to keep a shackle or two of cable ranged aft in preparedness for emergency tows.

Passing and securing the tow in submarines

In a conventional submarine the work involved in connecting the towrope **is** carried out on the bridge because of her low freeboard. The towing equipment fitted consists of a towing slip, which can be released from inside the hull and

fitted well forward, on which is a length of 1¼-inch chain cable with a swivel-piece shackled to its outboard end, the whole being led forward through the bullring. Shackled to the swivel-piece is a towing pendant of 3½-inch E.S.F.S.W.R. equal in length to approximately half the length of the submarine. The pendant is led aft along the starboard outboard side of the casing and then vertically up the starboard side of the fin to the bridge. It is clipped and faired along its length by soft metal clips to hold it in position.

Passing the tow. A snatch block is secured over the upper conning tower hatch and, after contact has been made by gun line fired from the submarine, a cordage messenger is hauled across, snatched into the block and led down the conning tower, where it is hauled by the crew inside the submarine. When the end of the towing hawser is received, the towing shackle is secured to the towing pendant and the hawser hung temporarily with a stout strand. The messenger is cast off and then the strand cut, allowing the towing pendant to tear out of its clips until its weight, and the weight of the towing hawser, are taken on the towing slip. If weather conditions are favourable the towing ship should be positioned on the starboard side of the submarine.

In a British nuclear submarine the system, known as 'blow tow', also does not require any personnel on the forward casing. A buoy is blown from the bows of the submarine by high-pressure air to a distance of approximately 200 ft. This buoy is then recovered by the towing ship. Attached to the buoy are 34 fathoms of 1½-inch buoyant polyethylene man-made cordage, 34 fathoms of 3-inch Nylon cordage and 34 fathoms of 1¼-inch chain cable.

The towing ship hauls in the polyethylene and Nylon, then secures the chain cable to her towing hawser.

Submarine tows of long duration. It is recommended that more than one chain cable bridle should be arranged or improvised, especially if heavy weather is likely to be encountered, because there may be a bad nip at the submarine end of the towrope, the nip cannot be freshened, and the small-sized cable may chafe through. Such preparations, however, can only be *planned* and achieved in harbour or sheltered waters. A second bridle can be secured to the outboard end of the submarine's anchor cable, but this precludes the use of her only anchor in emergency. It can also be secured by taking a turn round the conning tower, but this may be dangerous if the fitting at the fore end, through which the cable passes, should carry away and the submarine be girded. All bridles should, therefore, be secured outboard to a mooring ring of adequate strength, and the length of each varied so that should the first bridle part the next one would take the strain, and so on. The towing ship shackles her towing hawser to the mooring ring.

PRECAUTIONS WHEN TOWING OR BEING TOWED

Prevention of bad nips

Hawsers and cables should be given as fair a lead as possible, and any semblance of a bad nip should be corrected by using pad-pieces or bolsters of metal or hardwood. Hawsers should not be belayed to bollards having a diameter of less than four times the size of the rope. Cable, because of its construction,

is more susceptible to injury from a bad nip than is wire rope and therefore requires bollards of larger diameter than wire rope of equivalent breaking strength; cable should not be belayed to bollards having a diameter of less than twelve times the size of the cable. A ship's bollards are usually designed to take only her berthing hawsers, and are therefore too small for her cable; if her cable has to be secured to a pair of her bollards it is best done with a bollard strop and shackle.

Eliminating or reducing chafe

It is most important to prevent the towrope from chafing, or to reduce the effects as far as possible, where it passes through fairleads or hawsepipes. Hawsers should be parcelled with any hard-wearing materials such as canvas and sacking, or be served with rounding or junk. Fairleads and hawsepipes should be lined with soft wood covered with canvas or burlap, and grease or soft soap should be used liberally to minimise any chafe. Cable withstands chafing better than wire rope and is not therefore usually parcelled, but it should be kept well greased. Whenever practicable, arrangements should be made to freshen the nip of a hawser or cable. The nip of a hawser requires freshening more often than that of cable. The intervals between freshening the nip depend upon the amount of chafing experienced; in calm weather the nip of a cable is usually freshened every 24 hours, and that of a hawser between every four and eight hours.

The standard towing arrangements provided in a warship do not allow for the nip to be freshened. Frigates and some destroyers tow from a special slip fitted to the stern, and therefore there is no nip to be freshened. Cruisers and above and modern destroyers tow from their after bollards, the end of the towing pendant being shackled to a deck clench.

Connecting links

Lugged anchor shackles should always be used as connecting links in towropes, because they are long enough in the clear to take the eyes of the hawsers; they will pass through fairleads and hawsepipes and over obstructions without opening or being damaged, and they are positively locked by their pins and pellets. It is important to ensure that the shackles are as strong as the hawsers or cables with which they are used.

If an anchor shackle of suitable size and strength is not available, a grommet strop should be used as a connecting link. (The construction and strength of a grommet strop are described on page 117.)

A swivel is useful, though not essential, in a wire hawser composite towrope, and the best place for it is between the cable and the hawser. Swivels should not be used with Nylon towropes.

Strength of fittings

Men-of-war. The following table gives a comparison between the strengths of the various fittings and equipment used for towing in each class of man-of-war; the strength of the largest towing hawser supplied to the ship is taken as the unit.

	Towing hawser	Bollards on F.X. and A.X.	Forward capstan	Cable holder or windlass	Slips, stoppers and compressors	After capstan
Carrier	1	2·8	2·1	2·1	0·5	0·9
Cruiser	1	3·0	1·6	1·6	0·5	0·4
Destroyer	1	1·6	0·7	1·8	0·5	—
Frigate	1	1·2	—	1·2	0·9	—

Other ships. The windlass of a merchant ship is usually a little stronger than her cable, and her forecastle bollards are slightly weaker. Her guillotine, if fitted, should be stronger than her cable, and her devil's claw, or other cable stopper, is probably about one-third the strength of her cable.

Before subjecting a pair of bollards to a heavy stress its anchorage should be inspected, and if necessary it should be stayed by a well set-up guy led from the bollard farthest from the source of strain to a deck clench or other firm anchorage.

The ability of a bollard, capstan, windlass or cableholder to withstand the heavy stresses involved in towing depends largely on the strength of the deck to which it is fitted, and in small vessels or craft the deck may not be strong enough. In such vessels the towrope must be secured so that the towing stresses are distributed among as many strong fittings as possible, or the vessel must be towed by a girdle or necklace rove round the hull and stopped to the gunwale.

The base of a deckhouse or superstructure, the coaming of a cargo hatch and the base of a strongly stepped and robust mast or Samson post are probably the strongest anchorages for a towrope in a merchant ship, but it may be difficult to arrange a satisfactory lead for the towrope to such anchorages unless the ship is flush-decked.

PREPARATIONS IN SHIPS FOR PLANNED TOW BY OCEAN TUGS

Certain basic principles should be applied when preparing a planned tow, because ships vary in size and shape and each has to be treated individually. Several types and classes of ship have standard towing rigs available on application to the Director of Marine Services; but these rigs may have to be modified to suit the individual ship, because the positions of fairleads, bollards, etc. may differ in ships of the same class.

The method of rigging the towed ship, and the gear used in it, must satisfy the towing master, who is usually master of the tug and responsible for the safe delivery of the tow. If there is lack of uniformity in the preparation of the rig the towing master will require alterations to be made before he will accept responsibility; therefore the local naval authority or Dockyard department should always be consulted.

The towed ship can be a 'live' (manned) tow or a 'dumb' (unmanned) tow; unless the size and condition of the ship are unsuitable for manning, a tow should always be manned. Whether the tow is manned or not the difference in towing rig is slight. When manned, the towed ship should be able to slip the

towrope from inboard and the tug can then quickly recover it. When the tow is unmanned, the tug should be able to disconnect her towing hawser from a position just outboard of the towed ship; this entails manoeuvring close to the tow, and recovery takes much longer.

Trim. Excessive weight forward should be avoided, if possible; otherwise a towed ship may have to be ballasted. Ships should normally be trimmed 2 to 3 ft by the stern; the reasons for this are given in Vol. III.

Types of rig

There are three main types of towing rig: the two-tug rig for cruisers and above, the bridle rig for all other ships where there are adequate strong-points on the forecastle for securing the rig, and the necklace rig for those small vessels whose forecastle fittings are not strong enough for a bridle rig.

The two-tug and bridle rigs should be as simple as possible, using the strongest securing points and the most suitable fairleads. All gear must be sufficiently strong and must have been tested within the established periods for testing. A towing pendant is always included in the rig between the towing hawser and the ring, so that the towing hawser need not pass through and be chafed by a hawsepipe, bullring or fairlead when the ring is inboard, and to make it easier for the tug to shackle on her towing hawser to the end of the pendant, which is always outboard in a manned or unmanned tow. A spare towing pendant should always be provided by a manned tow and unmanned tow when the ring is inboard. It should be secured to the ring, led through the towing lead and stopped outboard to the heels of guardrail stanchions.

A slip should never be placed in the catenary of the towrope.

Swivels are not used in the tow now that tugs are fitted with self-tensioning winches, except when using a new towing hawser for the first time, when the slip may be supplied and rigged by the tug.

A preventer rig is essential in unmanned bridle or necklace rigs, desirable in manned bridle rigs, and unnecessary in two-tug rigs. It should be of E.S.F.S.W.R., be secured to a deck fitting or bollard strong enough to take the towing strain, and shackled to the mooring ring. It should be slack enough

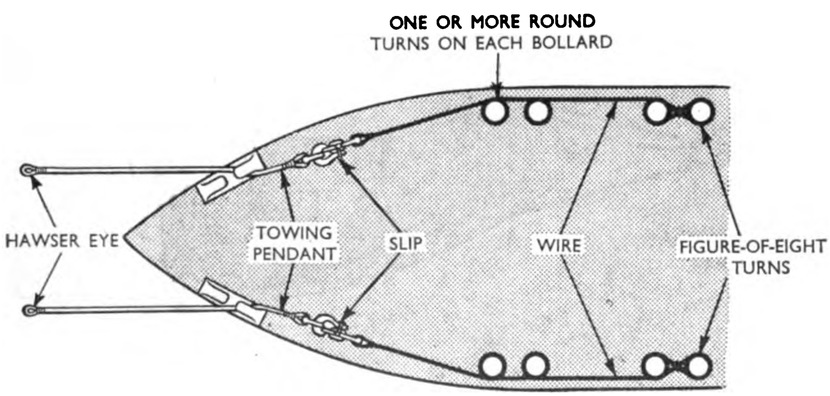


FIG. 10–6. Towing rig for manned tow—cruisers and above

to take no strain from the main rig, and it may be used as a recovery wire for the main rig after the tug has unshackled its towing hawser.

Two-tug rig. Cruisers and above are usually towed by two tugs with separate rigs each side of the forecastle. Each rig is secured to bollards and the towing pendant, led through a fairlead, is secured to the rig by a slip (fig. 10–6).

Two-legged bridle rig. This is the rig used for all ships with adequate forecastle securing arrangements other than cruisers and above. It consists of two wire or chain bridles originating from bollards (two pairs, if possible) on each

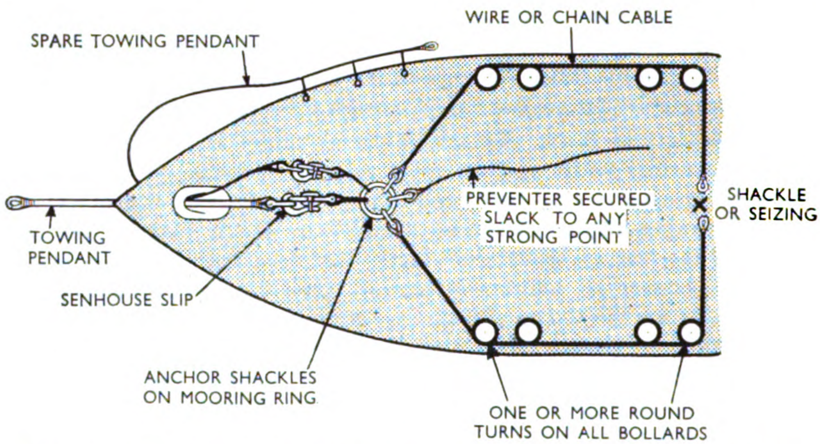


FIG. 10–7. Towing rig for manned tow—with bullring or stem hawsepipe

side of the ship and terminating at a mooring ring. The bridles are of wire rope for C.M.S. and below, and chain cable for larger ships. The mooring ring for a manned tow and unmanned C.M.S., with bullring or stem hawsepipe, is on deck; and a Senhouse slip, shackled to it, takes the tug's towing pendant (fig. 10–7). The mooring ring for an unmanned tow (not including C.M.S.) is outboard, so that it just touches the water when the bridles lead forward at an angle of 45 degrees (fig. 10–8).

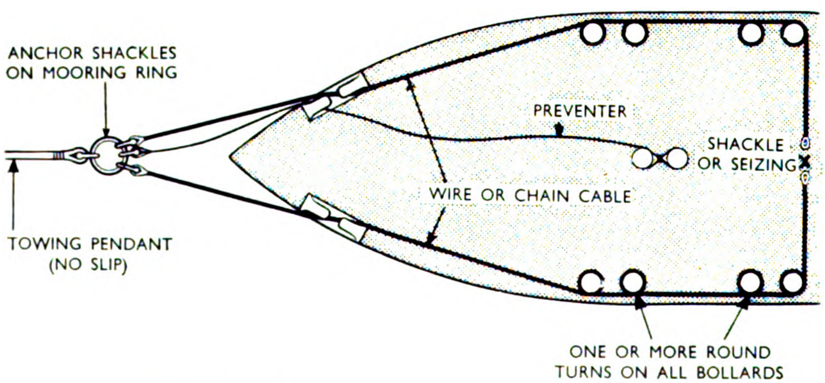


FIG. 10–8. Towing rig for manned tow not fitted with bullring or stem hawsepipe

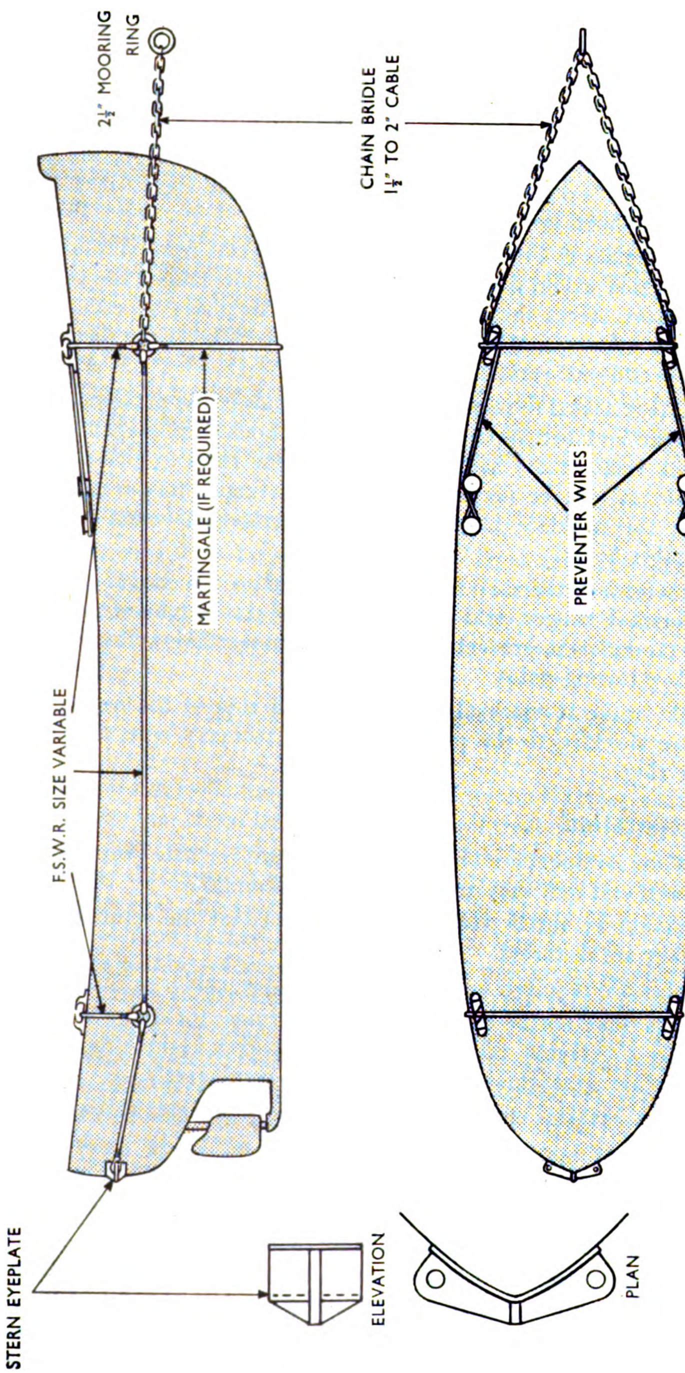


FIG. 10–9. Necklace towing rig

Necklace rig. Although lighters now under construction are being fitted with a bullring, deck clenches, bollards and fairleads, the necklace rig is still used for small vessels which lack deck fittings of adequate strength to secure a bridle rig. It consists of a necklace of wire encircling the hull of the vessel, supported by wooden chocks or wire pendants (hangers) rigged over the vessel's upper deck so that they support both sides of the necklace. Certain vessels—M.F.V.s, for example—have towing diagrams from which their rigs can be prepared; other small vessels for which no diagram exists should be rigged in a similar manner to that illustrated in fig. 10–9.

The fixed metal plate at the stern prevents the necklace from sliding bodily round the hull, which would give the tow a sheer to one side or the other. In vessels with transom sterns the necklace is secured to plates on each quarter and crossed at the stern so that the port necklace is shackled to the plate on the starboard quarter and vice versa.

The hangers are shackled to rings inserted at intervals in the necklace, thereby reducing the chafe and bad nips; and hardwood chocks are shaped over the deck edge in the wake of the hangers and under the rings to give a fair lead and reduce chafe. It may be necessary to rig a martingale forward under the hull to prevent the necklace from riding up, particularly when there is a pronounced tumble-home.

A preventer wire is fitted each side and shackled to the foremost necklace rings. If the forward hanger, which bears most of the weight of the towing hawser, parted on deck, the preventer would stop the necklace falling down and act as a secondary towing-point.

A chain cable bridle is shackled to each forward ring of the necklace, and the two legs are shackled to the mooring ring. A recovery wire may also be shackled to the ring.

Advice on preparation

1. Ensure that the components of the towing rig are 'in date' with regard to survey and test, and that they are all of suitable strength.
2. All wires should be fitted with hawser eyes, so that the thimbles can be changed if they are distorted.
3. Adaptor pieces are required when using forged steel cable.
4. Mooring rings must not be confused with boat rings; for example, a 3-inch boat ring looks substantial, but when compared with a 2½-inch mooring ring their strengths are approximately 18 and 60 tons respectively.
5. Lugged anchor shackles should be used for all connections to the mooring ring.
6. Demand towing gear by pattern number from the *Rate Book of Naval Stores*.
7. Have all bollards, fairleads and other strong-points surveyed: they may be defective in ships that have lain idle for long periods.
8. When rigging the gear, avoid bad nips and foul leads, especially where the bridles pass outboard. In unmanned tows the bridles should lead through fairleads, if possible, otherwise the hawsepipes must be used. Sharp edges play havoc with any rig; therefore no angle of lead should be less than 135 degrees.

9. Supply as much hardwood chocking as possible, especially in the way of deck fittings; grease all leads and deck edges.
10. When preparing a manned tow at least one anchoring device must be provided. Should the tow have to anchor and be unable to weigh, the anchor must be buoyed.
11. When securing the rig to bollards, start from forward so that the strain on each set of bollards originates from the bottom of the bollard.
12. *Navigation lights.*—All unmanned, and some manned, tows must have Propane gas navigation lights, which are usually supplied by the tug. Advice on the preparations for fitting the gas bottles and lights should be sought from the local naval authority.
13. An unmanned tow must be most carefully secured for sea; all openings should be sealed or closed, including navel pipes and vents. If there are adequate lubricating arrangements the propellers should be free to trail and the rudder should be locked amidships. If possible, the propellers of small vessels should be unshipped and lashed securely on deck.

Planned tows by ships other than tugs

When a ship is to be prepared for tow by a ship that has neither a self-tensioning winch nor a Nylon towrope, the normal planned towing rig cannot be used unless sufficient cable is inserted in the tow. Whether it is inserted by the towed or towing ship must depend on the circumstances.

SECURING HARBOUR TUGS

When a ship has to be handled in confined waters by tugs, each towrope must be secured so that it can be instantly slipped if the tug is in any danger of being girded; the tug must also be fitted with a slip. Many tugs have capsized, with fatal results, through not following this basic seamanlike precaution. The eye of the cordage or wire towrope must always be placed on a slip or, in the case of a wire towrope, turned up round bollards, kept in hand and backed up by an adequate number of seamen. As an added precaution against girding or any other emergency an axe should be provided in the ship and the tug.

Under normal conditions, when the towrope of a tug is to be slipped the tension should be eased before the slip is knocked off or the wire on the bollards surged roundly. Whatever the tension in the towrope the seaman knocking off the slip must stand well back and be prepared for either the slip, the towrope, or both, to fly up as the slip is released; the towrope backed up on bollards should be surged roundly under complete control, paying attention to the danger from its bights or fakes on deck.

Towing alongside

The best method of securing two ships alongside one another is by a head-spring and a backspring led from bow to quarter and quarter to bow, and by a forward breastrope and an after breastrope led from well forward and well aft in each ship. Both ships should be well fendered amidships. Provided that

the inner propellers of each ship are well clear of each other, the breastropes should be adjusted so that the ships lie parallel; but if there is a danger of the propellers fouling each other the bows of the ships must be bowsed in by the forward breastrope so that their sterns lie well apart.

If the towing ship is not particularly powerful or manoeuvrable she should lead the springs and breastropes so that her stern projects well abaft the other ship's stern. She will then find it much easier to manoeuvre and control the other ship than if she were secured abreast her.

TARGET WORK

Men-of-war are often required to tow various types of targets for surface or aircraft gunnery. The seaman should therefore have a working knowledge of the construction, size, rigging and towing arrangements of the targets described and illustrated in this section.

Surface targets supplied by the Director-General Ships, prefixed 'Mark', are allocated to Commands by the Navy Department; those supplied by the Director of Stores are prefixed 'Patt'. The Larne target is intended for manufacture by ship or local resources. The following terms are used when describing targets. A ***raft*** is a flat structure of beams and planks secured together to form a floating platform. A ***toboggan*** is a flat-bottomed hull or structure without runners and having its fore end curved up so that it skids over the water. A ***sledge*** is a flat-bottomed hull or structure fitted with runners for longitudinal strength. A ***sled*** is a small sledge.

Full details of all targets, their construction, towing arrangements and handling characteristics are given in B.R. 1596, ***Handbook on Targets.***

Twin-float splash target Patt. 8824

This consists of two elongated pear-shaped floats joined together by tubular bars and fitted with a towing shackle and stabilisers (fig. 10–10). It is used to

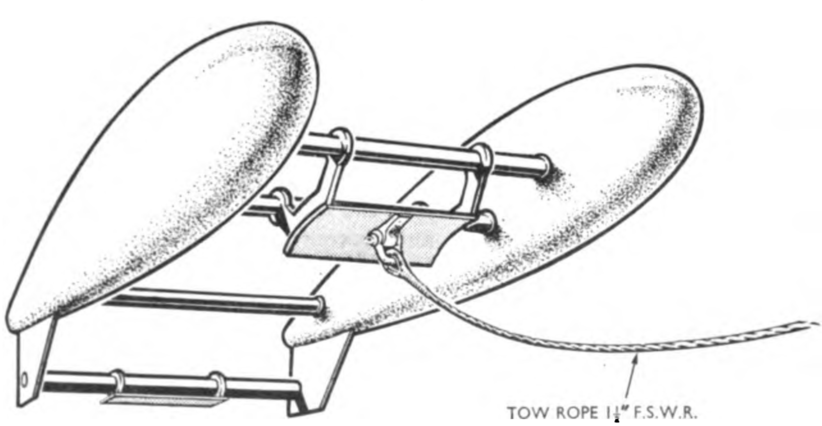


FIG. 10–10. Twin-float splash target, Patt. 8824

produce a plume of spray for giving a visible point of aim, and will also give a radar echo when towed at high speeds; the greater the speed the higher will be the spray. It can be towed at speeds of between 10 and 28 knots, using a towrope of 300 fathoms of 1½-in. F.S.W.R., and gives a reasonable point of aim for rocket and cannon attacks by aircraft, or for close-range surface practices. It can be carried on board. Because of its high cost this target should only be used when other targets are not available.

Larne target

This consists of a 5 ft by 4½ ft raft fitted with a planing board forward and three metal scoops aft (fig. 10–11). It has neither masts nor sails, but produces

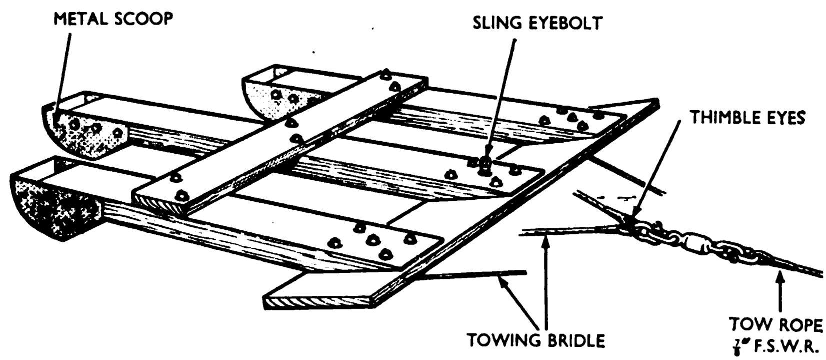


FIG. 10–11. Larne target

plumes of spray from the scoops. It is intended to be manufactured on board or by local resources, and its metal scoops can be drawn from Naval Stores. The target can be towed at speeds up to 30 knots, using a towrope of 360 fathoms of ⅞-in. F.S.W.R., though any small wire, e.g. Unifoxer or fog-buoy wire, can be used. It is designed to be carried in most men-of-war.

Pattern 2 target

This target consists of a wooden lattice-work structure (fig. 10–12), 28 ft long and 16 ft high, mounted on a wooden raft 30 ft long and 13 ft wide and stayed by three stays each side, each of 1-in. F.S.W.R. Two hessian sails are provided, each 5 ft wide and 30 ft long, which are laced to the lattice-work; in winds exceeding force 5 the sails should be furled, otherwise the target may capsize, dive to the bottom and break up. The towing bridle consists of two legs of 2½-in. F.S.W.R., each 10 ft long, the ends being shackled to eyebolts at the forward ends of the runners. A similar bridle is fitted aft to enable two or more of these targets to be towed in tandem.

This target is suitable for full-calibre practices by 4·5-in. guns and below, and it can be towed at speeds of up to 15 knots in calm weather, using a towrope of 360 fathoms of 2½-in. wire. For sub-calibre firings the length of tow should be not less than 300 yd, and for full-calibre firings it should be 750 yd. These targets are of little use at ranges of over 14,000 yd.

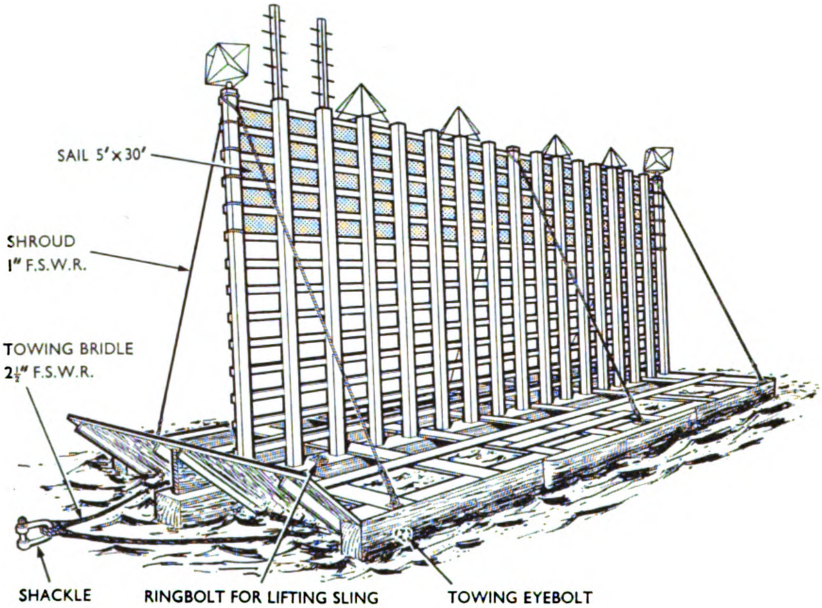


FIG. 10–12. Pattern 2 target

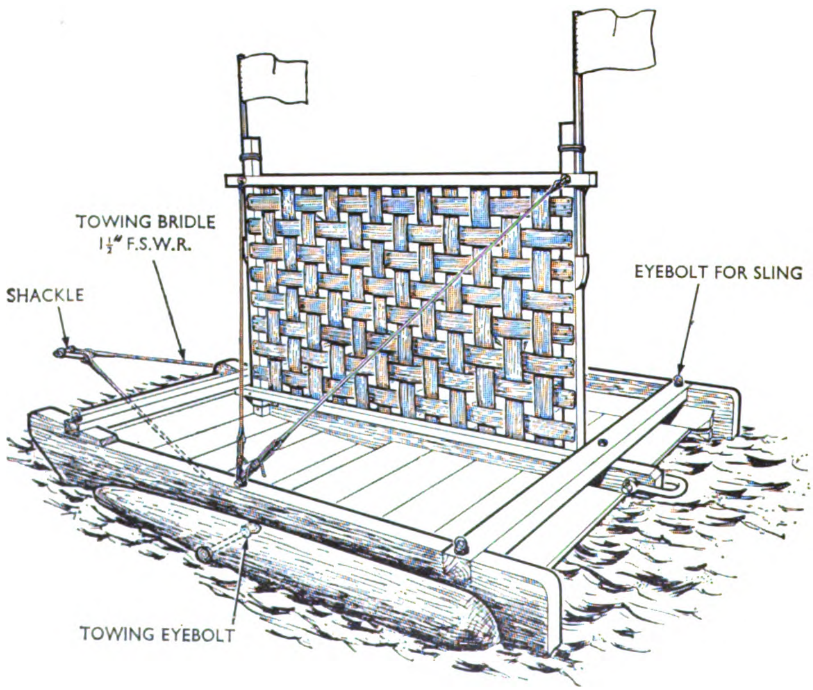


FIG. 10–13. Pattern 5 target

Pattern 5 target

This target (fig. 10–13) consists of a robust sled 8½ ft long and 5 ft wide, on which are stepped two masts, each 4½ ft high and stayed by two stays of ½-in. F.S.W.R. led to two eyebolts situated amidships on each side runner of the sled. The masts are fitted with a wooden frame to which are nailed interlaced strips of black hessian to form a sail 6 ft long and 4 ft high; the strips should be folded double to 3½-in. in width and stitched at their sides. A two-legged towing bridle 6 ft long of 1½-in. F.S.W.R. is shackled to two eyebolts situated amidships and on the inner side of the side runners; each leg of the bridle is rove through a lizard lashed to the side runner before the eyebolt. The target is also fitted with a 1-in. towing shackle to tow a second target in tandem. To hoist the target in and out it should be fitted with two slings of 1½-in. F.S.W.R., one on each side, and shackled to eyebolts at the end of each side runner, so that when the target is slipped from a trip-hook the slings will fall on their respective sides and clear of the masts.

The target is suitable for close-range weapons and rocket and cannon attacks by aircraft, and can be towed at speeds of up to 20 knots and in winds of up to force 5, using two 1½-in. F.S.W. ropes of 300 fathoms shackled together.

Mark 9 high-speed target

This target has a vee-bottomed, toboggan-type hull constructed of marine plywood moulded and secured to a wooden framework of ribs, stringers and beams. The raised bow and about 12 ft of the stem are decked, but otherwise the hull is designed to flood and drain freely so that punctures in the hull caused by gunfire do not affect stability or performance. The open transom acts as a large self-bailer when the target is under tow, and the two skegs (fixed rudders) fitted aft minimise skidding when altering course. Its length is 56 ft, beam 14½ ft, draught 3¼ ft, and it weighs 11 tons. Buoyancy is provided by thirty-eight containers filled with a plastic microcell composition such as 'Onozote'. Three masts of tubular steel 22 ft high are suitably stayed and braced, and two sails, 10 ft by 5 ft, are spread between their upper ends. The target is fitted with lifting plates and provided with a 3½-in. S.W.R. four-legged sling and a rectangular-shaped spreader; it should always be hoisted out of the water whenever possible, in order to avoid excessive soakage.

The towing arrangements consist of a centre line deck clench situated 21 ft from the stern. To this clench is shackled a Senhouse slip (for slipping the tow should it become foul on the bottom) to which is secured the unstudded end link of the 50-ft towing pendant of ¾-in. chain cable. The towing pendant leads forward through the hawsepipe, which passes through the bottom of the hull 20 ft from the bow. The forward end of the towing pendant is secured to the first swivel by two special shackles, and is triced up to the bow when not in use.

The target is towed at speeds of up to 26 knots by 625 fathoms of 2-in. E.S.F.S.W.R. into which are Talurit-spliced two 4-ft hanging eyes at 50 and 100 fathoms from the Senhouse slip end; these hanging eyes are used when transferring the target and towing hawser from one ship to another. To absorb any shock loading there is fitted between the towing pendant and towing hawser a double length of Nylon 12 fathoms long. When the towing pendant is not connected the target is towed from two additional towing shackles fitted on the

bow, and when so towed the speed of the target must not exceed 5 knots.

Mark 10 high-speed target

This target has a sledge-type hull and is fitted with deep runners. These are robust structures each consisting of two skins of 2-in. planking bolted and clenched together and joined by transverse planking, iron tie-bars and braces. Each runner has two steel keelplates fitted aft, designed to give the target stability throughout its speed range, and an inclined false deck extends from the bow for two-thirds the length of the target and acts as a planing board. The target's length is 51 ft, beam 8 ft, draught 6½ ft, and it weighs 5¼ tons. Buoyancy is provided by cork-filled buoyancy pads bolted to each runner, and by buoyancy tanks fitted forward. Four 12-ft masts are suitably stayed and braced, and wire netting (to improve radar reflection) and black or orange sails are spread between their upper ends. The target is fitted with lifting plates and provided with a 3½-in. S.W.R. four-legged sling; it should always be hoisted out of the water, whenever possible, to avoid excessive soakage.

The towing arrangements consist of a bridle of two 3-in. F.S.W.R. pendants 19 ft long, each tailed with 2¾ ft of ⅞-in. chain cable and joined by a circular forged metal link; to this link is secured a swivel-piece to which a ⅞-in. chain preventer is fitted from the bow of the target to keep it clear of the water; when the target is not in use this swivel should be triced up clear.

The target is towed at speeds of up to 26 knots by a composite towrope comprising (from the swivel on the target's bridle) 15 fathoms of 2½-in. E.S.F.S.W.R., a swivel-piece, 300 fathoms of 2½-in. E.S.F.S.W.R., a lugless joining shackle, a further 300 fathoms of 2½-in. E.S.F.S.W.R. with a 4-ft pendant Talurit-spliced 35 fathoms from the towing ship end, a swivel-piece, and 65 fathoms of 2½-in. E.S.F.S.W.R. with a 4-ft pendant spliced 50 fathoms from the towing ship end.

Variations of this standard towing rig may be found on different stations; therefore the seaman should ascertain which towing rig is in use before his ship assumes towing duties.

Mark 11 high-speed target

This target is 42 ft long and 26 ft wide and it carries a sail of 21 ft × 6 ft at a height of 21 ft above the hull. It is constructed of 12 in. × 6 in. baulks worked alternately fore and aft and transversely.

The target is fitted with a two-legged bridle connected to the 450 fathoms of 4-in. E.S.F.S.W.R. towrope by a three-eyed plate. The towrope is made up from three 150-fathom 4-in. E.S.F.S.W.R. joined by swivel-pieces. The target can be towed at speeds of up to 15 knots.

CHAPTER 11

Replenishment at Sea

The term *replenishment* means the restocking of a ship with men, munitions, stores, provisions, fuel or water. This chapter describes replenishment between one ship and another when both are under way at sea.

For a fleet to operate for long periods away from shore bases it must be replenished from specially equipped ships, and sometimes the larger ships must replenish the smaller ones. Standardisation of the method of connecting the gear has made replenishment at sea between ships of the NATO countries speedy and efficient, and sometimes quicker than when a ship replenishes in harbour. Replenishment must be accomplished in the shortest possible time consistent with safety, because the ships engaged are restricted in their movement and therefore more vulnerable to attack. However, speed of replenishment depends on the experience of the shiphandler and the efficiency of those working the gear; therefore a newly-commissioned ship will not normally attain the same speed of transfer as a ship which has carried out numerous transfers.

The shiphandling aspect of replenishment is given in Volume III.

METHODS OF REPLENISHMENT

A man-of-war can be replenished by store ship, tanker or another man-of-war, and to a limited extent by helicopter and inflatable liferaft. Liquids, such as fuel and water, can be transferred by the *abeam* method, when the supplying ship and the receiving ship steam close abreast; or by the *astern* method, with the receiving ship astern of the supplying ship when fuel only is supplied. During the transfer it is usual for the supplying ship to maintain a steady course and speed and for the receiving ship to keep station on her. Stores, munitions, provisions and men are transferred by the abeam method, though small quantities and numbers may be transferred by *helicopter* or *inflatable liferaft*.

Abeam transfer of solids and personnel

Solids are transferred by the *jackstay method*, in which the loads are slung from a block, called the *traveller*, which is hauled along a jackstay rigged between the two ships. There are two types of jackstay rig—the *light jackstay rig*, which is designed for the transfer of loads of up to 500 lb or men singly, and the *heavy jackstay rig*, which may be for loads of up to one ton, or up to two tons, depending on the supply ship's capacity.

Transfer of liquids

Liquids are transferred with the ships steaming abreast or with the receiving ship astern of the supplying ship, the liquid being pumped through hoses rigged as follows:

Abeam method. The hose is secured in, and supported by, troughs slung

outboard from the supplying ship's derrick or crane, or from travellers running on a jackstay rigged between the two ships. The former method is known as the *derrick fuelling rig* or the *crane fuelling rig*, and the latter as the *jackstay fuelling rig*.

Astern method. Either the supplying ship streams the buoyant hose astern of her and the receiving ship, then approaches the end of the hose, grapples it and hauls it in through her fuelling roller fairleads and then connects it to her fuelling system; or the receiving ship closes the supplying ship and the hose end is transferred to her by gun line, messenger and hose line. In either case the rig is known as the *astern fuelling rig*.

NOTE.—Most of the items of replenishment-at-sea gear are Naval stores and are listed in the relevant Permanent Loan List. ATP 16, *Replenishment at Sea*, must be studied for details of the rigs, communications, etc.

GENERAL REQUIREMENTS

Distance abeam or astern

A steady course and speed by the supplying ship and correct station-keeping by the receiving ship are most important. During abeam transfers the distance

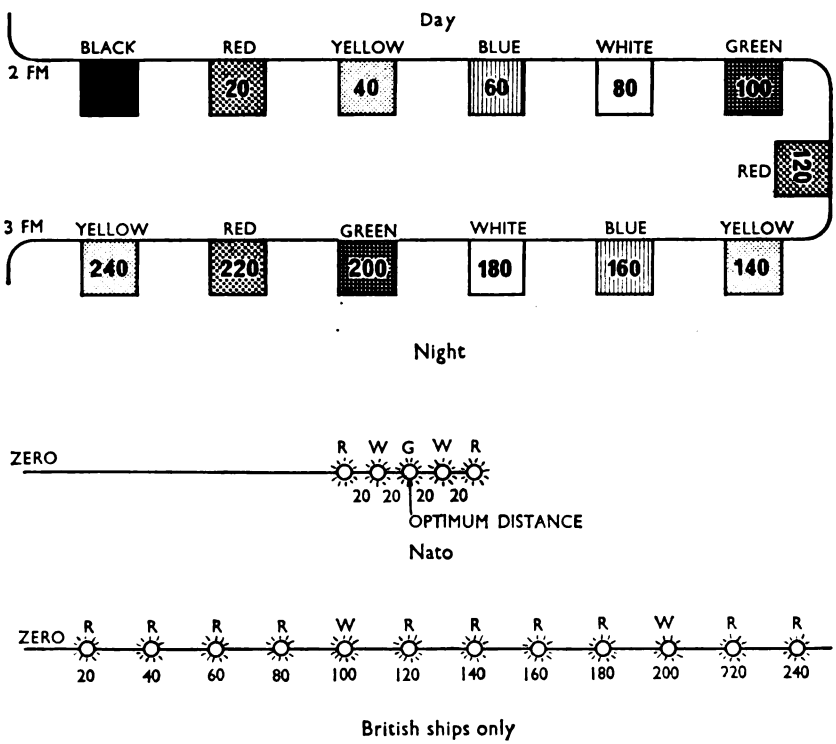


FIG. 11–1. The distance line

between the two ships is measured by a *distance line*, which consists of 45 fathoms of 1½-in. cordage, marked at the zero position (2 fathoms from one end) with a piece of canvas painted black, and then at intervals of 20 feet with pieces of coloured canvas with the distances painted on them (fig. 11–1). The standing end is hitched to the supplying ship's guardrail at the zero mark, and the other end is kept taut in the receiving ship at a position visible from the bridge and at right-angles to the fore-and-aft line. During replenishment in rough weather the line can be led through a leading block and tended from a sheltered position.

At night the distance line used between ships of NATO countries is marked with a green light at the optimum position and a white light 20 feet each side of the green, and a red light 40 feet each side of the green. Individual countries may have other ways of marking the line for use only between their own ships. The light system used between British ships is a white light every 100 feet from the zero position and a red light at each intervening 20 feet.

When fuelling astern, the receiving ship keeps station on a marker buoy veered by the supplying ship a distance which is less than the length of the hose.

Communications

For all methods of transfer, communication between the two ships may be by telephone, voice radio, loud-hailer, megaphone or hand flags, but normally the telephone is used except for transfers of short duration and when fuelling by the astern method. The telephone cables are supplied by the ship which supplies the remainder of the gear (usually the supplying ship), and provision is made for direct communication between the bridges of the two ships and between each dump or fuelling position.

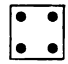
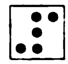
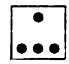
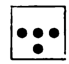
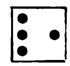
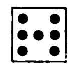
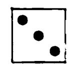
Marking of transfer positions

For abeam transfers the transfer positions (stations) in each ship are marked by square hand flags or a pattern of red lights in a box to assist in the initial stages of passing the transfer gear (see table on page 386).

Establishing contact for abeam transfers

When each ship has equal facilities, the supplying ship provides all lines and gear required for the transfer; but for transfers between small ships (such as frigates) and larger ships (such as aircraft carriers and cruisers) the lines and gear are always provided by the larger ship. When replenishing from a specially-designed replenishment ship, the supplying ship always provides the lines and gear. Contact between the ships is established with a special Nylon line called the *gun line*, which is projected by a line-throwing rifle fired by a man wearing a red coat and helmet. The gun line is provided by the supplying ship, i.e. the ship which provides the lines and gear, though the receiving ship should always have one available in case it is required. The exceptions to this rule are the aircraft carrier, because of the risk of damage to parked aircraft and the awkward positions in which the rigs are connected, and ships carrying dangerous cargoes on deck; they should always fire the gun line whether they are supplying or receiving.

System of Marking Transfer Positions

Commodity transferred	*By day (flag)*	*By night (red lights)*
Fuel oil	Red	
Stores	Green	
Ammunition	Green	
Gasoline and Avgas	Yellow	
Lubricating and diesel oils	Blue	
Jet fuel or Avcat	Yellow-blue triangles	
Water	White	

When all other personnel in both ships have taken cover and the officers in charge of the stations have declared by whistle that they are ready to fire or receive the gun line, the rifle is aimed so that the line will fall across the transfer position and the order is given to fire. A messenger is then hitched to the bight of the gun line and hauled over. When in hand in the receiving ship, the various lines (distance line, telephones, outhaul, etc.), which are tallied, are hitched to the messenger at intervals of six feet, then paid out with the messenger and hauled in by the receiving ship. The method of hitching is with a foot length of double gun line seized to an Inglefield clip, so that the distance line, for example, may be unclipped immediately on arrival in the receiving ship. The double gun line tails may be spliced into the messenger.

If more than one transfer is to be carried out and the positions in the receiving ship are far apart, two or more gun lines are projected so that all rigs are passed and secured in the shortest time.

Fig. 11–2 shows the method of establishing contact and passing the gear for a light jackstay transfer between a cruiser and a destroyer. The gun line and messenger are hauled across; the distance line, telephones and outhaul are then unclipped and the outhaul is led through a leading block and run in until the end of the grommet strop of the jackstay can be secured to the receiving ship's slip. (Details of the different rigs are described and illustrated later in this chapter.) When passing gear from one ship to another the bights of the lines should not be allowed to trail in the water, as the resultant drag might haul the gear out of hand or part the messenger.

Provision for emergency

In all forms of replenishment, provision must be made to slip or cut away

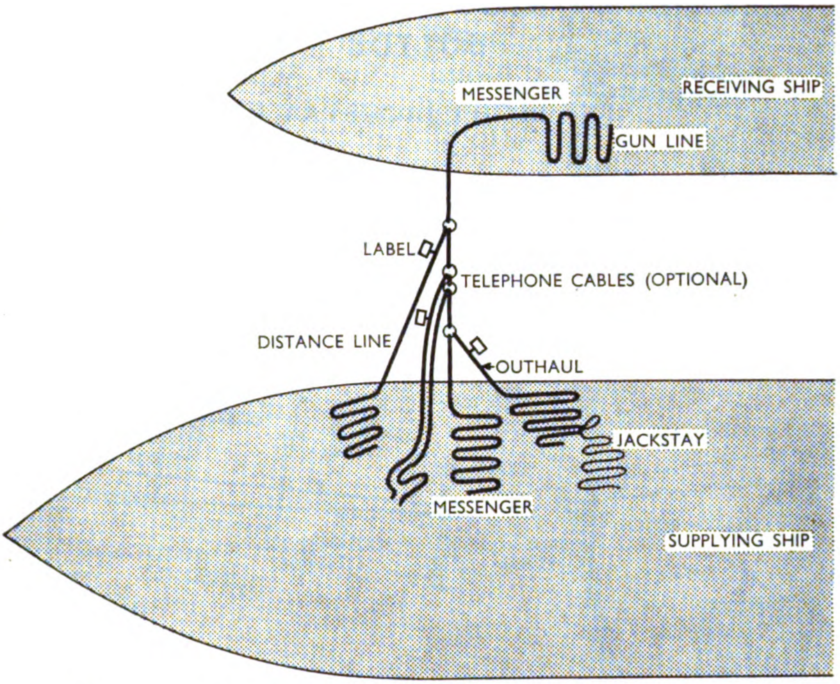


FIG. 11–2. Transfer by light jackstay: establishing contact and passing the gear

the gear connecting the two ships in an emergency. Hands should be ready to slip the gear, and axes and mauls should be provided at each transfer station. An emergency breakaway should normally be an accelerated disengagement, passing the gear back in the normal way, because any damage to the gear in an emergency breakaway will undoubtedly delay further replenishments while the supplying ship recovers and repairs the gear or replaces those items which have been damaged or cut.

If transferring by the light or heavy jackstay and the traveller is moving, it must continue to the end of its run and be brought to rest; it should never be reversed. As soon as the traveller has stopped and the load has been unhooked, the jackstay should be checked away so that the receiving ship can slip it in safety.

When transferring fuel, hands should be ready to disengage couplings, jackstays and pendants; and lines must be faked down on deck ready for running. The supplying ship must be ready to stop pumping.

Normal disengaging after abeam transfer

The gear should be passed back in the reverse sequence to that in which it was received, care being taken to keep the different lines separated. The last length of line should be paid out to its bitter end and not be stopped in a coil and cast overboard, because the drag of the coil might well be too much for the recovering ship, or the line might part.

DETAILS OF RIGS FOR TRANSFERRING SOLIDS

THE LIGHT JACKSTAY RIG

The light jackstay (fig. 11–3) is used for transferring men (singly), provisions or light stores, and the safe working load (500 lb) of the rig must never be exceeded. The hauling end of the manila jackstay is manned by at least 20 men in the ship supplying the gear, and the other end is secured by its grommet strop to a slip in the receiving ship. The traveller is hauled back and forth along the jackstay by an *outhaul* in the receiving ship and an *inhaul* in the supplying ship, manned by a suitable number of men.

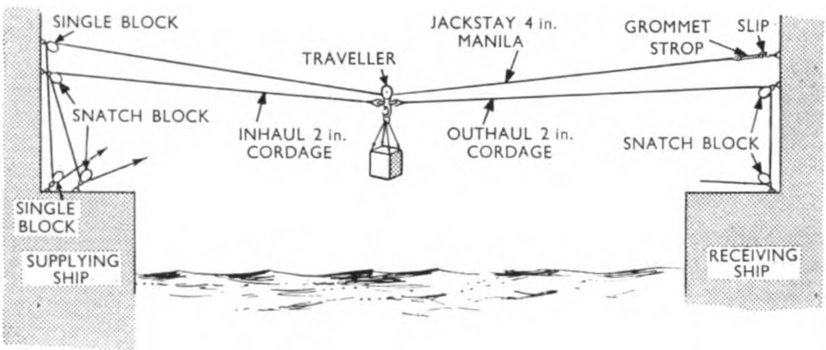
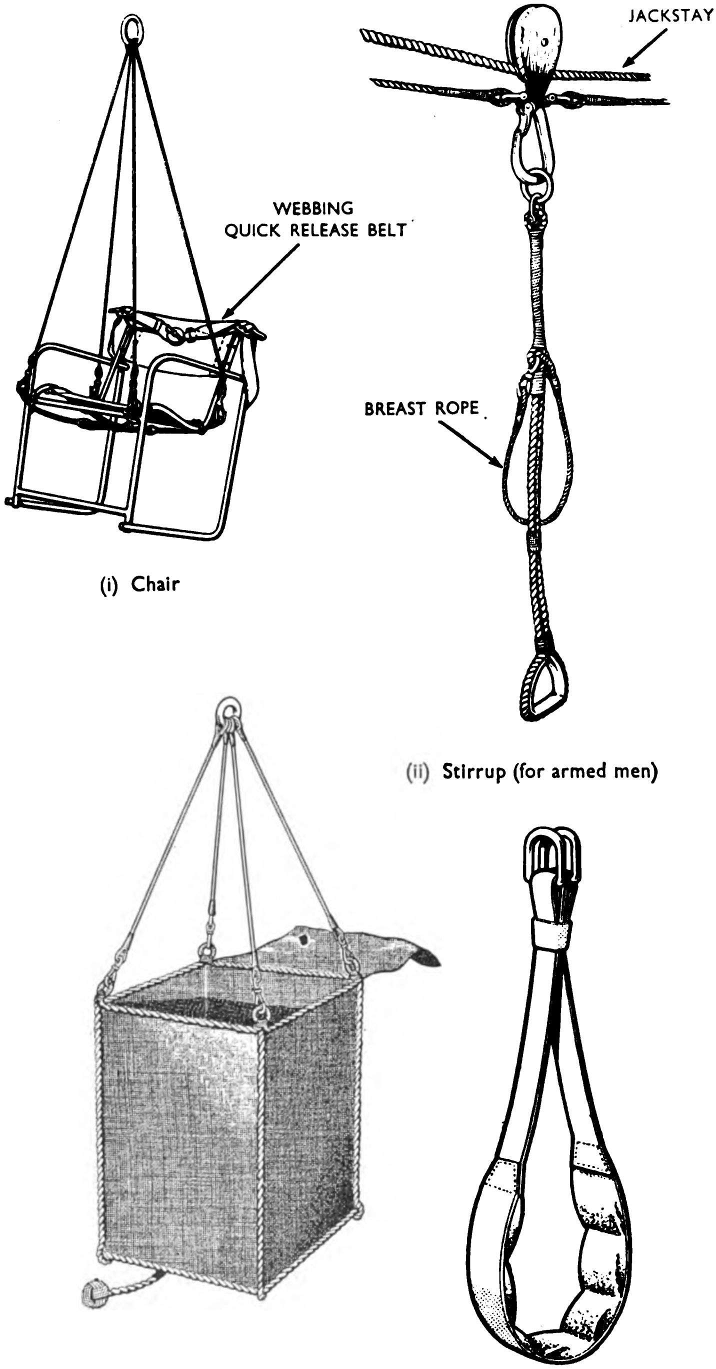


FIG. 11–3. The light jackstay rig

Small miscellaneous stores are best transferred in a canvas container (fig. 11–4); other stores may be slung from the traveller hook or transferred in provision nets. Men are transferred by helicopter rescue strop, by chair, or by a stirrup if they are armed (fig. 11–4). They must always wear lifejackets.

Strength of rig

When setting up any rig of the jackstay type the stresses imposed on certain parts of it depend on the tension in the jackstay and they may greatly exceed the weight of the load being transferred. The tauter the jackstay the greater will be the tension in it when the load is slung; conversely, the slacker the jackstay the less this tension will be. When the angle made in the bight of the jackstay is 120 degrees, for example, the tension in it will be equal to twice the weight of the load, and if the jackstay becomes bar taut the tension will rise to infinity (see page 197 and Volume I). The tauter the jackstay, however, the easier it is to haul the traveller back and forth. In practice the tension in the jackstay depends on the pull exerted by the men manning it, and will seldom exceed the safe working load of the rope; but since the stress on the leading blocks and their shackles and eyeplates will be much greater than any tension in the jackstay, these items have safe working loads far in excess of the maximum.



(i) Chair

(ii) Stirrup (for armed men)

(iii) Canvas container

(iv) Helicopter rescue strop

FIG. 11–4. Light jackstay transfer gear

It is prudent to allow for stresses of as much as ten times the weight of the load to be transferred.

Position for the rig

The jackstay is led to a point in both ships high enough above the deck to allow the load slung from the traveller to clear the guardrails when they are raised, and far enough inboard to allow the traveller to plumb the dump. The area of the dump should be large enough to accommodate an accumulation of stores and a handling party of six men, and it should be about 12 ft by 12 ft if possible. There should be clear runs of at least 60 ft for the men manning the jackstay, the inhaul or the outhaul, and a clear run for the supply or removal of stores to and from the dump. The rig should be simple and have as few leading blocks as possible for the jackstay, outhaul and inhaul, because the friction in each block reduces the overall efficiency.

Passing and rigging the gear

By the ship supplying the gear. The messenger, distance line, telephone cables (if required), outhaul and jackstay (each tended by one or two men) are faked down on deck. As soon as the gun line is passed it is bent to the messenger, which is then hauled across. When the messenger is in hand in the receiving ship, the distance line, telephone cables and outhaul are clipped to the messenger, and the jackstay is secured to the bight of the outhaul by a toggle. The whole lot are paid out handsomely as the messenger is hauled in by the receiving ship. When the grommet strop at the end of the jackstay has been secured to its slip in the receiving ship and the toggle removed, the slack of the jackstay is taken down and the first load is slung on the traveller ready to be hauled across. Before transferring at night, or when transferring men by this method, a test load must always be sent across to ensure that the traveller or other lines are not foul round the jackstay and that the gear has been properly rigged.

By the ship receiving the gear. The gun line is hauled across and then the messenger. As each line attached to the messenger comes inboard it is unclipped; the distance line is taken to the forecastle, the telephone cables are connected to the bridge and transfer position telephone plug-boxes, the outhaul is snatched into its leading block (secured to the lower of the two eyeplates) and hauled in until the grommet strop of the jackstay is close to the slip shackled to the upper eyeplate. The strop is then secured to the slip, the messenger is faked down, kept rove or passed back to the supplying ship, and the gun line is coiled up and hitched to the messenger or returned to the supplying ship.

Working the rig

Two hands should be detailed for hooking on or unhooking loads, the traveller being kept in hand between loads. The jackstay is walked back so that the load can be hooked on; then it is hauled taut to lift the load off the deck. The receiving ship then hauls out the load until it is over the dump; then the supplying ship eases out the jackstay to lower the load.

Obstructions in the vicinity of the dump and the deck edge must be well

padded with fenders or other suitable material to avoid damaging the loads; paunch mats should be placed on the deck, except where pallet trucks are used to clear the dump. All hands in the replenishment area must wear lifejackets, partially inflated. At night the lifejackets must be complete with whistle and light. When the guardrails are slipped and down, temporary guardrails must be set up and manned, so that they can be lowered when a load is about to be received or despatched.

Returning the gear

When the last load has been transferred, a sufficient length of the outhaul is retained in the receiving ship so that a bight can be toggled to the jackstay to take its weight while the slip is released, and then to pay it back to the supplying ship, keeping it clear of the water. The distance line and telephone cables (if used) are paid back at the same time and their ends then cast overboard. At night the distance line is tailed with a short messenger to keep the lights clear of the water. The ends of telephone cables should be protected by a polythene waterproof bag.

NOTES:

(i) It may be the practice for the messenger and gun line to be returned to the supplying ship as soon as possible after the jackstay has been connected; or for the messenger to be retained between the two ships for miscellaneous transfers and the gun line returned; or for the messenger and gun line to be retained and faked down in the receiving ship, then returned bent to the end of the outhaul and paid out to the bitter end.

(ii) In suitable weather conditions the messenger may be dispensed with; then the gun line would be hitched to the end of the outhaul and the other lines secured to the outhaul, as described above when the messenger was used.

THE HEAVY JACKSTAY RIG

This rig is used for the transfer of heavy loads of stores, including ammunition, up to a maximum of one or two tons, depending on the size of the gear being used. Unless an automatic tensioning winch is fitted in the supplying ship to control the catenary of the jackstay, this rig can be used safely only under reasonably good weather conditions.

A typical heavy jackstay rig, by which loads of up to one ton can be transferred, is shown in fig. 11–5. In principle it is very similar to the light jackstay rig. The jackstay and the supplying ship's inhaul are worked by winches in the supplying ship, and the receiving ship's outhaul is worked by the warp end of a winch, by capstan or by hand. The jackstay and inhaul are of E.S.F.S.W.R. and the outhaul of Nylon. The method of passing, rigging and working the gear is very similar to that for the light jackstay rig, but when passing the gear the jackstay is secured to the outhaul by a toggle wedged through a bight of the outhaul which has been passed through a becket spliced into the jackstay near its end.

Stores and ammunition are transferred on slings, in cargo nets, or in special containers. Obstructions in the vicinity of the dumps should be well padded to

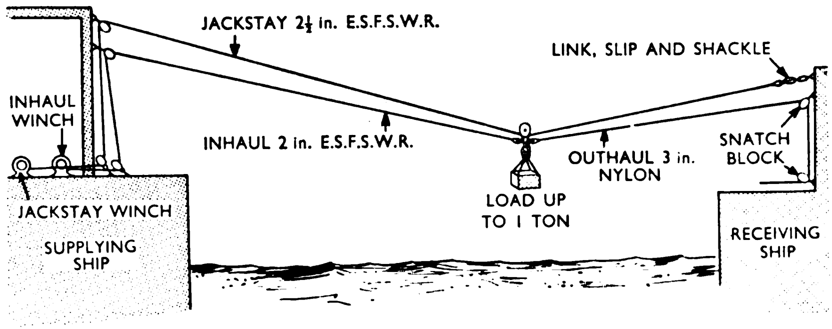


FIG. 11–5. Heavy jackstay rig (one-ton rig)

protect the ship's structure and the stores; decks should be protected by paunch mats, except where pallet trucks are being used to clear the dump.

A test load must always be transferred before storing is started, and—with the exception of this test load, which is landed on deck and sent straight back—all loads must be unhooked from the traveller before being dispersed.

DETAILS OF RIGS FOR TRANSFERRING LIQUIDS

Fuel may be transferred from a cruiser and above to a smaller man-of-war by the crane or small derrick method as the two ships steam abreast, or by the astern method. R.F.A. tankers can fuel men-of-war by the large derrick, jackstay, or astern methods. This section describes the general working of the crane or small derrick rig, the jackstay rig and the astern rig.

FUELLING ABEAM: MAN-OF-WAR TO MAN-OF-WAR—CRANE FUELLING RIG

Aircraft carriers and other major warships may be required to fuel destroyers, frigates and other small vessels at sea. The abeam method is normally used, and a typical rig for an aircraft carrier is shown in fig. 11–6. Some aircraft carriers may be fitted with a fuelling boom (derrick); however, the general principles described below for the crane rig would still apply.

The hose is slung from the supplying ship's crane in two troughs, the working trough on the crane purchase, and the static trough on a 3-in. manila tackle secured half-way along the jib of the crane with the hauling part led through a leading block on the flight deck, where it is manned or taken to a suitable power unit. A recovery line of 1½-in. F.S.W.R. (or 3½-in. manila, if it has to be man-handled) is shackled to the securing adaptor and clamp, which is 15 ft from the end of the hose (fig. 11–7); it takes the weight of the end of the hose when it is offered to the receiving ship and when it is being recovered after fuelling. This line is rove through one leading block at the head of the crane and another on the flight deck, where it is manned or taken to a suitable power unit.

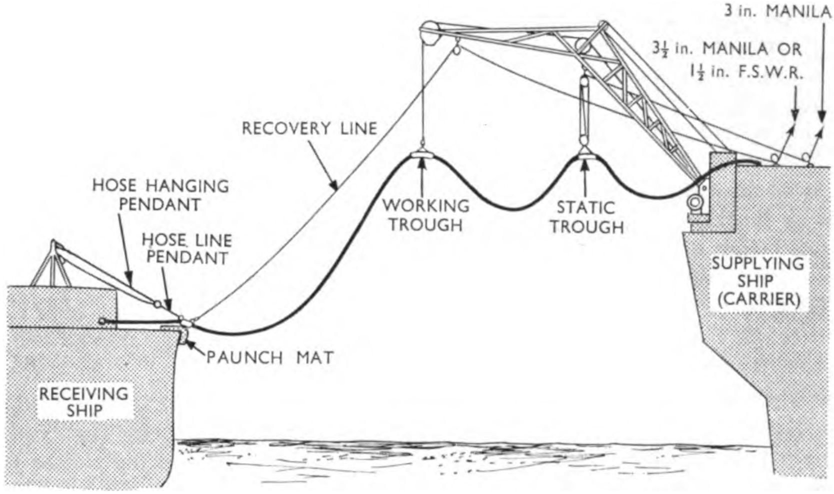


FIG. 11–6. Fuelling abeam: man-of-war to man-of-war—crane fuelling rig

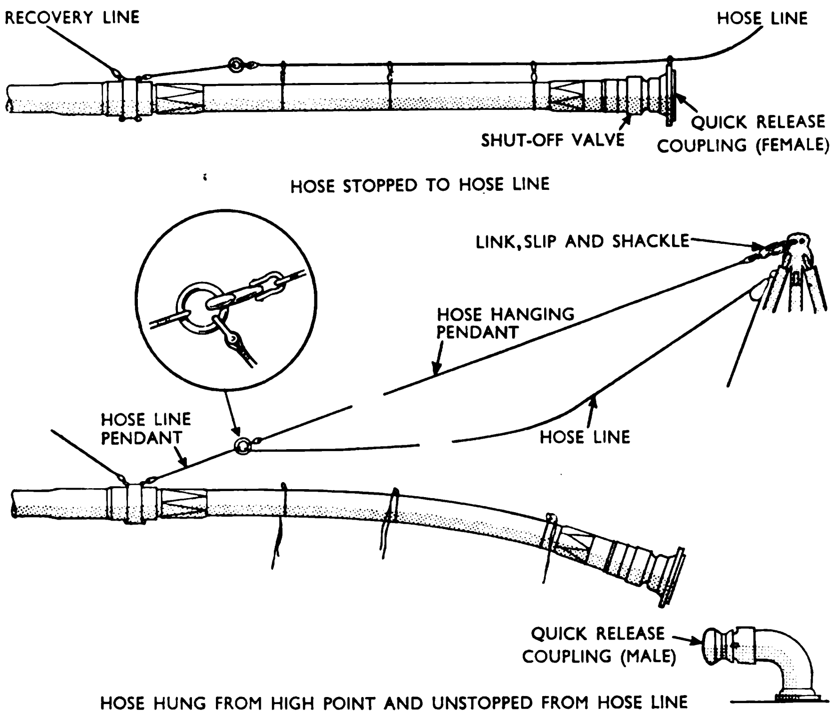


FIG. 11–7. Rig of end length of hose

A hose line for hauling the end of the hose aboard the receiving ship consists of 30 fathoms of 1½-in. manila tailed to 40 fathoms of 3½-in. manila, shackled to a ring which is connected to the hose adaptor and clamp by a 3-ft hoseline pendant of 2½-in. F.S.W.R. (fig. 11–7). When the end of the hose has been hauled aboard it is hung by a hose-hanging pendant of 2½-in. F.S.W.R., which is hooked to the ring between the hose line pendant and the hose line and secured on a slip at least 8 ft above the deck. The outer 15-ft length of hose has 1½-in. rings permanently lashed along its length, and to each ring is spliced a 4-ft length of 1½-in. cordage which is secured to the hose line by a slip knot (fig. 11–7). When the hose is hauled aboard the receiving ship, each line is slipped in turn until the length of hose is completely free from the hose line and can be manhandled into position for joining to the receiving ship's fuelling connection.

A shut-off valve is fitted in the end of the hose, and the hose is connected to the receiving ship's fuelling system by a quick-release coupling (fig. 11–7). The female portion is sent across from the supplying ship on the end of her hose, and the male portion is provided by the receiving ship. The coupling operates on the probe and drogue principle and on the female portion there is a handwheel which operates three dogs holding the coupling in engagement. The handwheel has two working positions: RELEASE and ENGAGE. When ships of different countries are transferring fuel from one to another a breakable spool quick-release coupling is used (fig. 11–8). Of the two parts of this coupling the 'B' section is sent across from the supplying ship on the end of her hose, and the 'A' section is provided by the receiving ship.

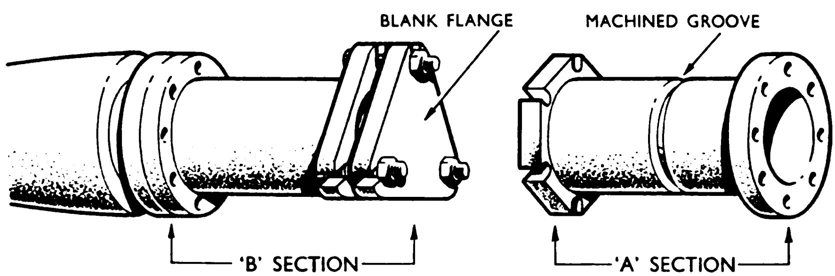


FIG. 11–8. Breakable-spool quick-release coupling

Rigging the gear in the supplying ship

Hoses are supplied in 30-ft and 15-ft lengths. Five 30-ft lengths and a 15-ft length are coupled together and then connected to the flight deck fuelling connection. To the outer end are connected the shut-off valve and the female portion of the quick-release coupling.

The static and working troughs are placed at about 30 ft and 80 ft respectively from the flight deck fuelling connection, leaving 70 ft of hose from the working trough to the securing adaptor and clamp, which is 15 ft from the end of the hose. The hose is lashed in the troughs and protected from chafe by canvas gaiters laced round the hose. The inboard and outboard 15-ft lengths of hose are protected by sword matting and lashings. The recovery line and hose line

pendant are shackled to the securing adaptor and clamp, and the end 15-ft length of hose is secured to the hose line by the slip-knotting of each lashing.

The crane purchase is hooked to the slings of the working trough, and the static trough tackle and recovery line are positioned and rove through their leading blocks. The recovery line and hose line are tended and the troughs are hoisted into position.

Passing the gear and rigging it in the receiving ship

The supplying ship establishes contact in the normal manner, i.e. by gun line and messenger, and when the messenger is in hand in the receiving ship the supplying ship clips the distance line, telephone cables and hose line to the messenger, in that order. As the hose line is passed the crane is trained outboard.

When the hose line is hauled aboard the receiving ship it is snatched into its leading block, which is placed at least 15 ft above the fuelling position, and hove in. As the end of the hose comes inboard the slip knots securing it to the hose line are slipped, care being taken to ensure that when each line is slipped the hose does not damage its end fittings by hitting the deck; and when sufficient hose is inboard the hose-hanging pendant is hooked into the ring between the hose line pendant and the hose line. The hose line is then eased until the hose-hanging pendant takes the weight of the hose. The hose is coupled and pumping can begin. Temporary guardrails are rigged as soon as possible after connecting up.

Paunch mats are placed under the hose to protect it from chafe, and the hose is kept from working sideways by two tackles suitably secured to the securing adaptor and clamp. These tackles should always be tended; otherwise they will part when the ships yaw apart and the hose rises from the deck.

Working the rig

The relative positions of the ships will be continuously altering and the rig must therefore be tended in the supplying ship throughout the transfer. The bights of the hoses should not be allowed to trail in the sea, and the crane should be trained in line with the lead of the hose to avoid any sideways stress on the jib-head. When the ships close, the working trough is raised and the jib is topped up; when they open, the working trough and jib are lowered. The static trough requires little adjustment unless the ships open to nearly the full scope of the rig.

Disengaging

Towards the end of fuelling the gun line and the end of the hose line are returned to the supplying ship. A cordage sliprope is then rove through the ring of the hose line, and one end is secured to the high point and the other manned or led to a winch. When fuelling has been completed and the hose has been uncoupled and stopped to the hose line, the sliprope is hove in until the weight of the hose is taken off the hose-hanging pendant, which is then unhooked from the ring. The sliprope is then veered until the recovery line has the weight of the hose, after which the sliprope is released, either by cutting it at the high point or slipping it if the end secured to the high point is on a slip. The telephone cables and distance line are cast off in the usual way.

The receiving ship must never release the end of the hose until the supplying ship has complete control of the hose, otherwise the crane may be strained and the gear damaged.

FUELLING ABEAM FROM A TANKER— LARGE DERRICK FUELLING RIG

This is usually the standard rig for R.F.A. tankers when supplying fuel to all but the larger units of the fleet. The preparations and methods of passing the gear and disengaging are exactly the same as those described above for the crane fuelling rig (though the messenger may be dispensed with and the various lines would be hitched directly to the hose line tail). The derrick, which is longer than a ship's crane, has the fuelling hose slung from it in three troughs, i.e. the static, inner and outer troughs. A greater length of hose can be used, and therefore the distance between the two ships can be increased.

FUELLING ABEAM FROM A TANKER— JACKSTAY FUELLING RIG

When tankers replenish larger units of the fleet, the jackstay fuelling rig is normally used, because the distance between the two ships can be greater than when using the crane or derrick rigs. A single jackstay fuelling rig is similar to the heavy jackstay rig for transferring solids, but the jackstay carries several travelling blocks to support the hose in troughs (fig. 11–9).

The rig consists of a 3½-in. E.S.F.S.W.R. jackstay, 85 fathoms in length, secured to a slip in the receiving ship and led through blocks at the head and foot of a kingpost to an automatic tensioning winch in the tanker. The hose is lashed in four troughs: one is triced to the head of the kingpost and the other three are slung on travellers which run along the jackstay. A 3-in. E.S.F.S.W.R. recovery wire is shackled to the second and third trough travellers and a 1½-in.

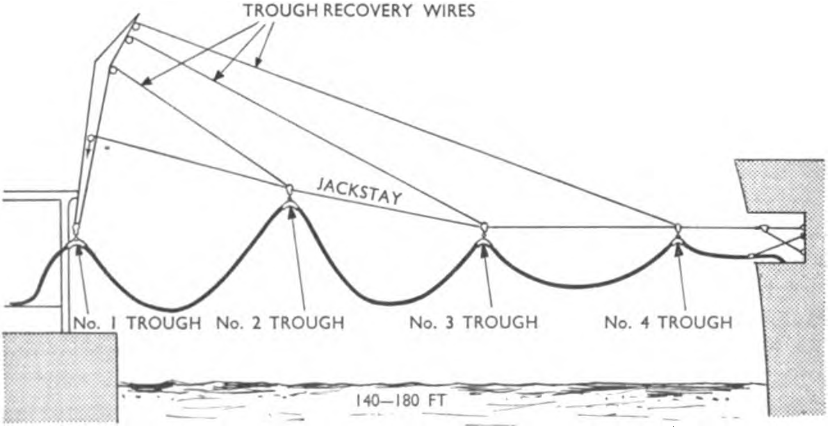


FIG. 11–9. Fuelling abeam from a tanker—jackstay fuelling rig

E.S.F.S.W.R. to the fourth trough traveller. These recovery wires are led through leading blocks at the head and foot of the kingpost to separate winches.

On the outboard end of the jackstay is shackled a monkey plate, to the second eye of which is shackled a 3½-in. E.S.F.S.W.R. jackstay pendant, and on the end of this is a steel link for securing to the slip in the receiving ship. To the third eye of the monkey plate is shackled the 3½-in. manila jackstay line, which is used to haul the jackstay across from the tanker after initial contact has been established (fig. 11–10). Hitched to the monkey plate is the end of the 3½-in. manila hose line, which is hove in after the jackstay has been secured and moves the hose troughs across the jackstay.

Working the rig

Contact is established and the lines are passed from tanker to man-of-war in the same way as when using other rigs. The jackstay line is snatched into the leading block situated below the high point in the receiving ship and hove in until the link at the end of the jackstay pendant can be secured to the slip. The jackstay line is then unsnatched from the leading block and the hose line cast off the monkey plate and snatched into the same leading block. The hose line is hove in until the end of the hose is inboard, and the trough wires are eased out in the supplying ship as necessary. The receiving ship then hooks the hose-hanging pendant into the ring, veers the hose line until the pendant has the weight of the hose, and couples up the end of the hose to her fuelling system (fig. 11–10).

Disengaging

When fuelling has been completed and the hose uncoupled, the hose line is hove in until the weight of the hose is off the hose-hanging pendant, which is then unhooked from the ring. The supplying ship heaves in the trough recovery wires as the hose line is paid out from the receiving ship. The messenger is secured to the hose line about 30 ft from its end and paid out until the hose line has been recovered in the supplying ship. The jackstay line is now snatched into the leading block and hove in until the jackstay can be slipped and then paid back to the supplying ship. All other lines are now paid out and cast off in turn, care being taken that only one line is in the water at a time.

FUELLING ASTERN FROM A TANKER— ASTERN FUELLING RIG

The tanker streams from her stern a buoyant spout-type float, which identifies the end of the rig and helps to keep it near the surface. Attached to the float is a hose line of 40 fathoms of manila, or 50 fathoms of man-made fibre cordage tailed to 10 fathoms of wire, which is followed by the buoyant hose. About 40 ft from the outer end of the hose line is a becket, used when slipping the rig. The length of hose streamed by the tanker depends on the weather; about 450 ft are streamed in calm weather and about 630 ft in rough weather.

The tanker also streams a *marker buoy* on which the receiving ship keeps station by keeping it abreast her bridge. The distance to which the marker buoy

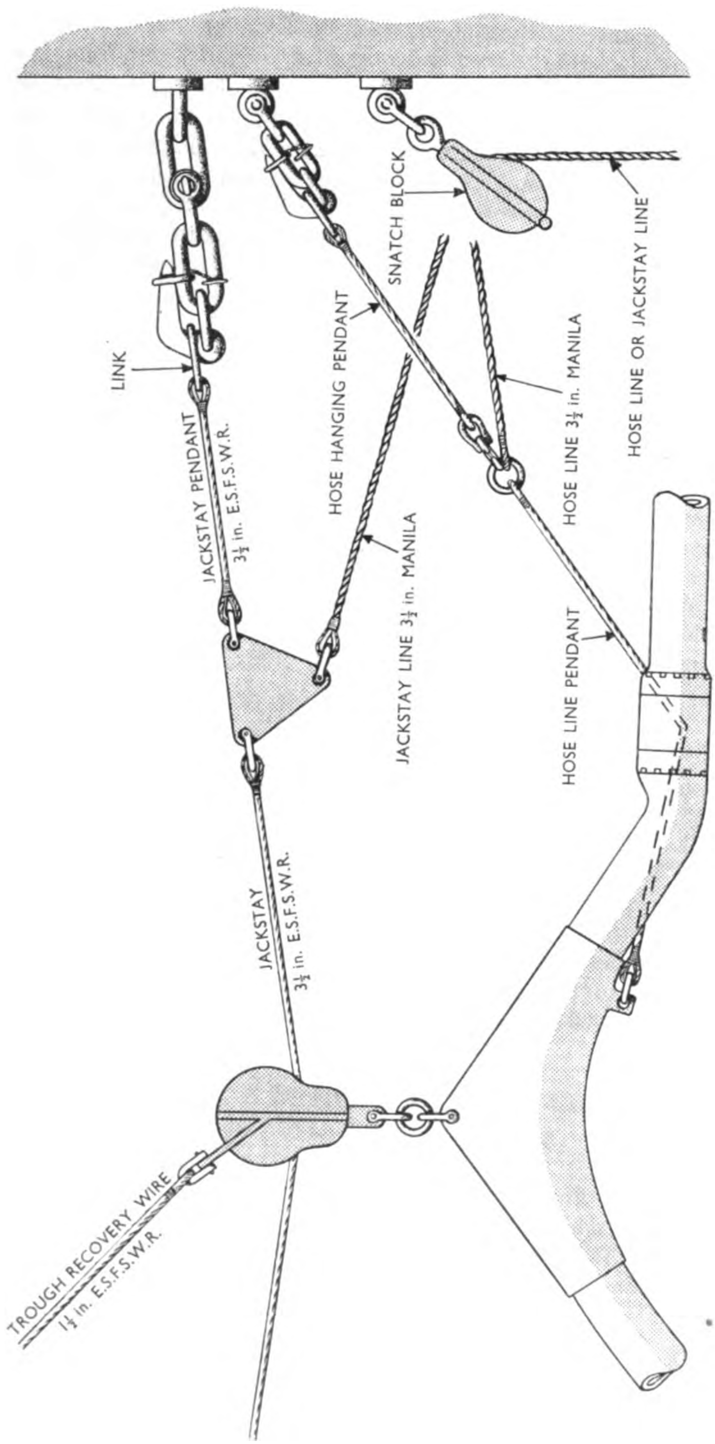


FIG. 11–10. Jackstay fuelling—securing arrangements

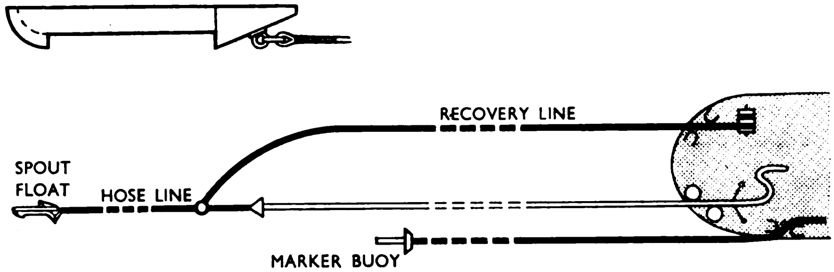


FIG. 11–11. Fuelling astern: rig streamed by tanker (inset, spout float)

is veered is adjusted to allow a deep bight in the hose when it is connected; the bight allows for slight errors in station-keeping (fig. 11–11).

Hose-end rig

To the securing adaptor and clamp (15 ft from the end of the hose) is shackled a two-legged bridle (fig. 11–12), which is connected to a ring by a short bridle pendant. On the ring is a link by which the hose is hung from a slip and securing pendant in the receiving ship. Also shackled to this ring are the end of the hose line and a hose cap pendant with a swivel which is shackled to the conical cap on the end of the hose. The length of the bridle and its pendant is a little shorter than the end 15 ft length of hose and the hose cap pendant, to ensure that the weight is always taken by the bridle and not by the hose.

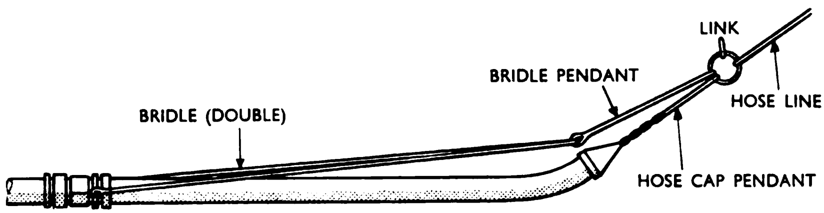


FIG. 11–12. Fuelling astern—hose-end rig

Establishing contact

There are two ways of passing the end of the hose from the tanker to the receiving ship: the *float method*, in which the tanker streams the hose line and hose, and the receiving ship grapples the float on the end of the hose line and then hauls in the end of the hose; and the *gun line method*, in which the tanker streams the bight of the hose and the receiving ship approaches close enough to the tanker's quarter to receive a gun line by which the end of the hose line is transferred. The float method is the better in bad weather when astern fuelling is likely to be used, and the hose line may be passed from one replenishing ship to the next by gun line.

The float method. To assist the receiving ship in grappling the hose line a grapnel (creeper) is secured to the hose line about 6 ft before the float, so that when the receiving ship closes the hose line her grapnel, when cast over the hose line, will engage with the creeper, preventing the grapnel from sliding

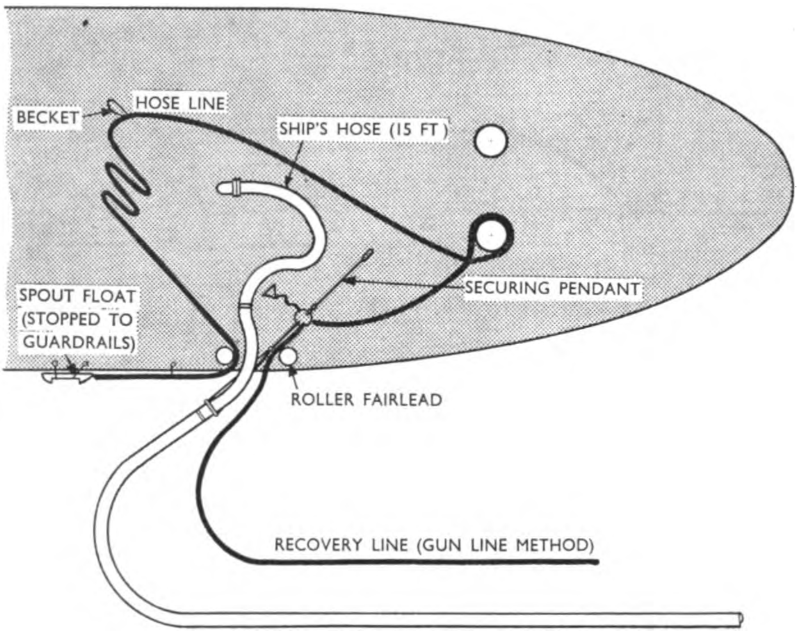


FIG. 11–13. **Fuelling astern—forecastle arrangements in receiving ship**

down the hose line and fouling the float. To facilitate the grappling of the hose line a shackle should be secured to the grapnel line at a distance from the grapnel equal to about the freeboard of the forecastle. The grapnel is thrown across the hose line at least 15 ft before the float and when it hits the water the bight of the grapnel line is let go slack so that the grapnel line straddles the hose line.

When the hose line is grappled its bight is led through the fuelling roller fairlead and the float and creeper are stopped outside the guardrails abaft the fairlead. As much as possible of the hose line is hauled in by hand as the receiving ship moves up to the fuelling position abreast the marker buoy.

When the end of the hose is abaft the fairlead the hose line is brought to the capstan and the end of the hose is carefully hove up to the lip of the fairlead, guided through it and hung by its slip and securing pendant. The hose line is kept on the capstan and racked as a preventer. The hose cap is removed and the hose is then coupled up to the receiving ship's 15-ft length of hose already coupled to the fuelling connection (fig. 11–13). The signal to start pumping is then passed to the tanker.

The gun line method. The hose line and a hose recovery line are shackled to the ring of the hose-end rig. When the hose is streamed its end is held close astern of the tanker by the recovery line while the remainder is streamed in a bight, as shown in fig. 11–14(i).

The receiving ship closes the quarter of the tanker and the gun line is fired. To this is hitched a light messenger which, in turn, is bent to the end of the hose line; the messenger may be omitted if the receiving ship can approach close enough.

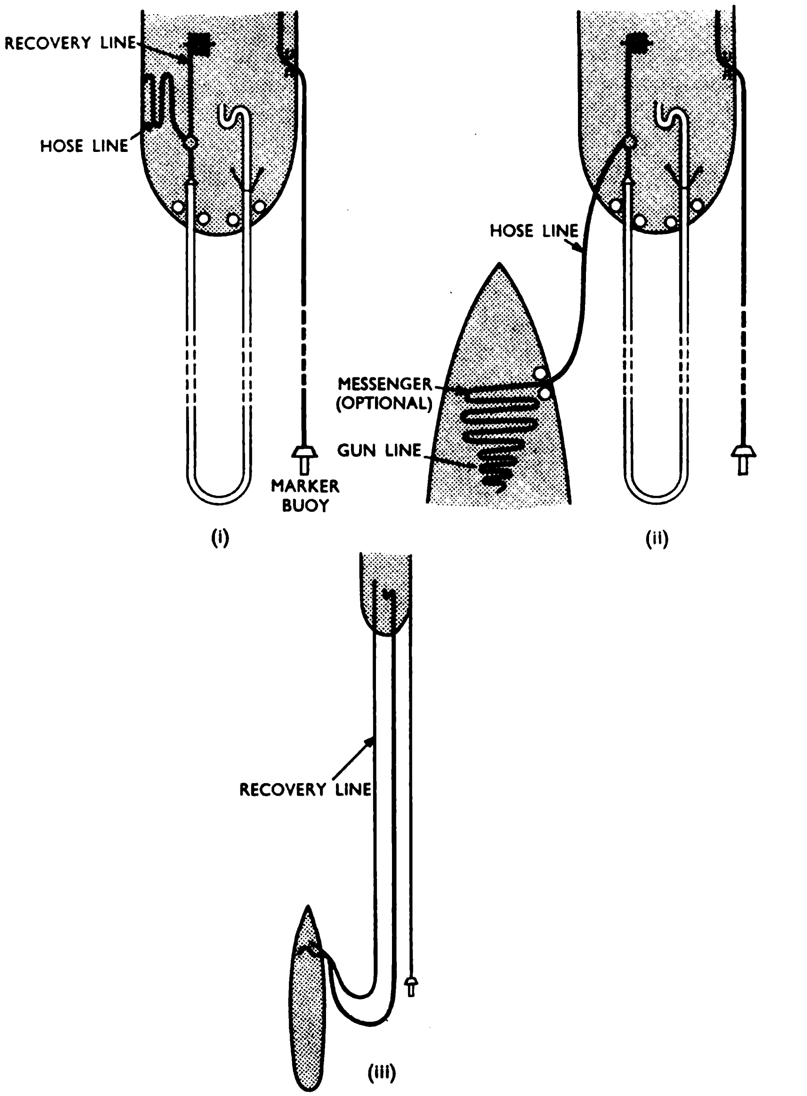


FIG. 11–14. Fuelling astern—gun line method

When the hose line is in hand in the receiving ship she drops astern while the end of the hose is paid out on the recovery line from the tanker (fig. 11–14(ii)). When the receiving ship is in position abreast the marker buoy she hauls in the end of the hose with the hose line and couples up the hose to her fuelling system (fig. 11–14(iii)).

Disengaging

Slip rope method (fig. 11–15(i)). This is the best way to ensure that the hose line float will not foul the propeller. A slip rope is rove through the hose line

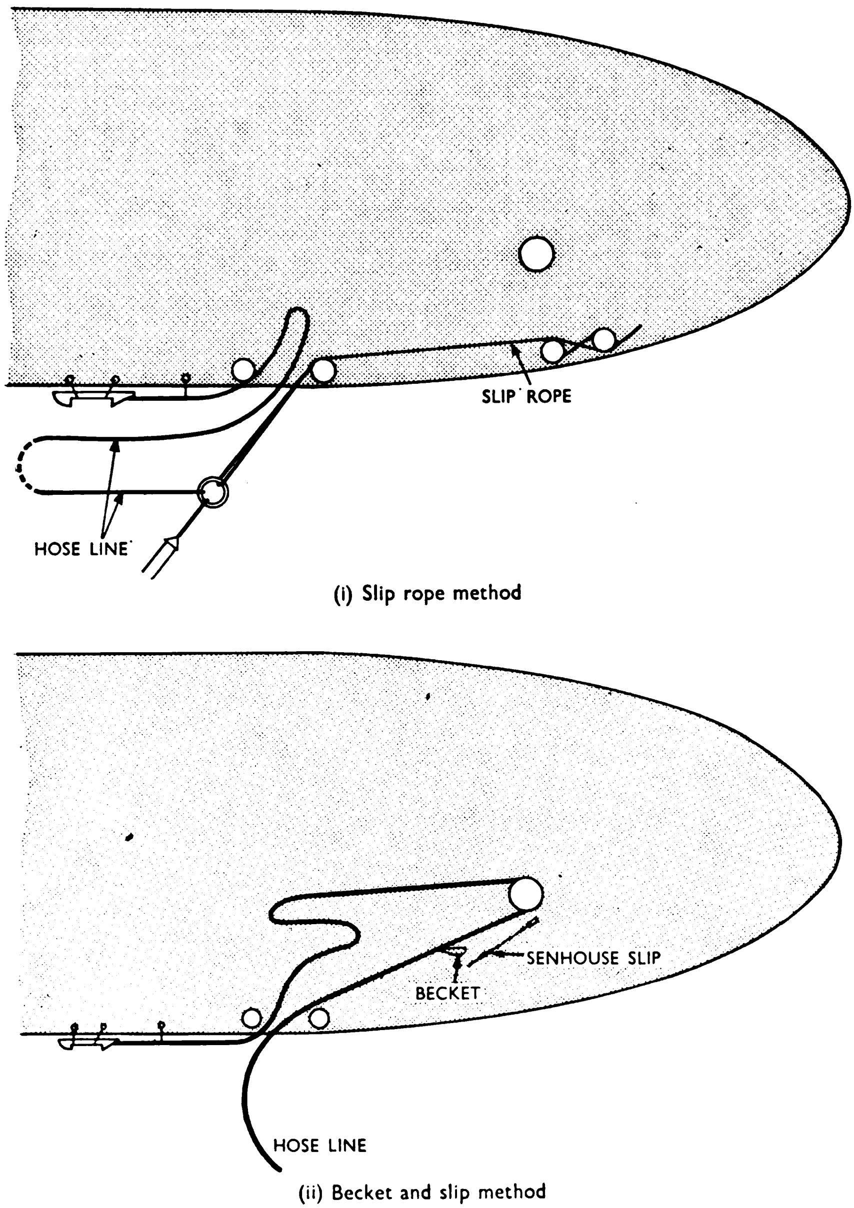


FIG. 11–15. Fuelling astern: disengaging (i) slip rope method; (ii) becket and slip method

ring. The hose line is then hove in, the slip knocked off and the hose line veered until the ring is outside the roller fairlead, when the slip rope is belayed to take the weight of the hose. The hose line can now be paid out on the bight. The ship meanwhile has reduced speed by about three knots and the hose is slipped by surging or cutting the slip rope when the bight of the hose draws towards the beam. Finally, the float stops are cut when there is no risk of the float fouling a propeller or the hose line.

Becket and slip method (fig. 11–15(ii)). The hose line is faked for running abaft the capstan and on its disengaged side, and the becket (40 ft from the inboard end) is stopped securely to it to prevent it from being fouled as it passes round the capstan. Make sure that the end with the float and creeper is stopped securely outside the guardrails abaft the hose fairlead.

The hose is uncoupled and its cap replaced. The hose line on the capstan is unracked and the weight of the hose is taken off the securing pendant by the hose line. The securing pendant is then slipped, and the end of the hose is veered handsomely on the hose line through the hose fairlead and into the water. As the hose line is veered the bight in the hose decreases and when the becket is abreast the slip there is little strain. The becket is then unstopped and put on the slip; the hose line is taken off the capstan, and its bight is passed out through the hose fairlead. The stops securing the end of the hose line and the float are then cut, the becket is slipped and the hose line and float should stream clear of the ship.

Gun line method. The receiving ship uncouples the hose, replaces the cap and pays out the end on the hose line; then she closes the tanker, while the tanker hauls in the end of the hose with the recovery line. When the receiving ship is sufficiently close the tanker passes another gun line, to which the receiving ship hitches the messenger (or gun line if no messenger was used when establishing contact), and the end of the hose line is then passed back to the tanker.

If another ship is to refuel astern immediately, the hose line is transferred by gun line, with or without a messenger, to the other ship on the opposite side to the hose. The hose is not recovered by the tanker.

FUELLING ASTERN FROM A MAN-OF-WAR

Most major units of the fleet are equipped for fuelling another man-of-war astern of them. Here is described briefly a typical arrangement for an aircraft carrier acting as a supplying ship.

About 450 ft of hose is provided and streamed in three or more fleets from a hose fairlead rigged at the after end of the flight deck. The first fleet must be started out, but the others should stream by their own weight and the drag of the water. As the inner end of each fleet approaches the hose fairlead, it is hung on hose-hanging pendants and coupled to the outer end of the next fleet. The inner end of the last fleet is hung on the hose-hanging pendants and coupled to a length of hose leading from the supplying ship's after fuelling connection.

Rigging the gear (fig. 11–16)

A starting-out wire of 1½-in. G.F.S.W.R., fitted with a hook, is rove through

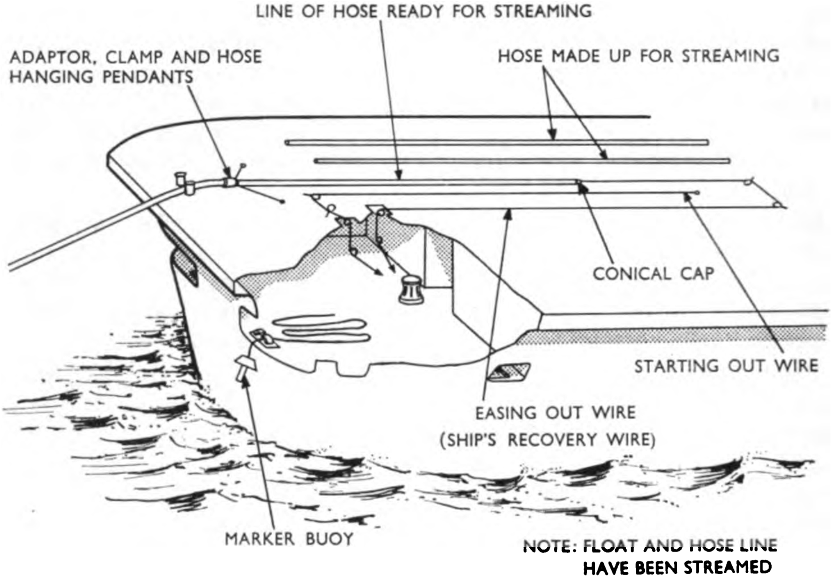


FIG. 11–16. Fuelling astern—aircraft carrier

two leading blocks, round two portable rollers, all of which are situated just forward of the hose fairlead, and led to the after capstan on the quarterdeck. An easing-out wire of 2½-in. G.F.S.W.R., which also serves as a recovery wire when recovering the hose, is rove through two leading blocks situated well forward on the flight deck, round a portable roller and then also led to the quarterdeck and turned up on bollards.

The end 15-ft length of hose is rigged in the usual manner (fig. 11–12) and the hose line is led out through the hose fairlead, brought back inboard with the float attached, and faked down on the flight deck. The hose-hanging pendants are shackled to screwed eyebolts about 15 ft before the hose fairlead. On the quarterdeck the marker buoy and its wire are prepared for streaming through a fairlead on the opposite side to the hose.

Streaming the hose

The float and hose line are streamed and the hose is then started out by heaving in on the starting-out wire, the easing-out wire being surged as required. When the inner end of the first fleet is near the hose fairlead it is hung on the hose-hanging pendants; the conical cap is removed and the first and second fleets are coupled. The easing-out wire is then shifted to the inner end of the next fleet of hose, the starting-out wire taken off the capstan and first fleet of hose, the easing-out wire brought to the capstan, hove in until the hose-hanging pendants can be removed from the first fleet of hose, and then veered under power, allowing the second fleet to be streamed by the weight of the hose and the drag of the water. If the starting-out wire is required for this second fleet, the easing-out wire remains on the bollards and the starting-out wire on the after capstan.

When the inner end of the last fleet of hose is near the hose fairlead it is hung on the hose-hanging pendants and then coupled to the length of hose rigged from the carrier's flight deck fuelling connection. When the hose has been connected it is inflated. The marker buoy is streamed to the required length.

Recovering the hose

The marker buoy is recovered, and then the hose is hove in by the recovery wire, using the after capstan. As the outer end of each fleet is brought aboard, the hose is hung on the hose-hanging pendants and the fleet uncoupled from the next one. The recovery wire and conical cap are then transferred to the end of the next fleet, which is hove in in a similar manner. When the last fleet has been recovered the hose line is run in through the hose fairlead and the float brought aboard.

TRANSFER BY INFLATABLE LIFERAFT

When adverse weather conditions or lack of time do not justify the usual methods of transfer of personnel or stores, other methods must be adopted. One method is to transfer by inflatable liferaft, using direct contact between the two ships, called the ***normal transfer;*** or using direct contact between the two ships, the supplying ship then standing off, this being called the ***outhaul transfer;*** or with no direct contact between the two ships, this method being called the *free transfer*.

In this section it is intended to describe the inflatable liferaft to be used, its special rigging, its lowering and hoisting arrangements, the details of the three transfers mentioned above, and hints to the occupants of the liferaft.

The liferaft

A special inflatable liferaft, circular in shape, is sometimes supplied to H.M. ships for this type of transfer. Its fabric in the wake of possible chafe is protected by additional material; if it is to be lowered or hoisted lifting arrangements are fitted, and if it is to be hoisted when containing a load the floor is strengthened by a metal hoop with a circular canvas cover laced inside it and the hoop then lashed to the underside of the raft. When the raft is strengthened it can be hoisted with three men or the equivalent weight of stores; but it is generally advisable to lighten the raft, if possible. Six men or the equivalent weight of stores can be transferred when the raft is waterborne.

A raft which has not had its floor strengthened must be emptied before it is hoisted, but in an emergency—for example, when transferring a stretcher case—it can be hoisted without significant damage to the flooring.

It is recommended that the liferaft used for the transfer of personnel or stores should be properly fitted and rigged to allow it to be hoisted on board when loaded.

Details of the rigging

Liferaft to be hoisted without load. The rig consists of a 2½-in. manila grommet short-spliced, with two round thimbles diametrically opposed seized into the grommet and the grommet fitted tightly round the waist of the raft. Shackled

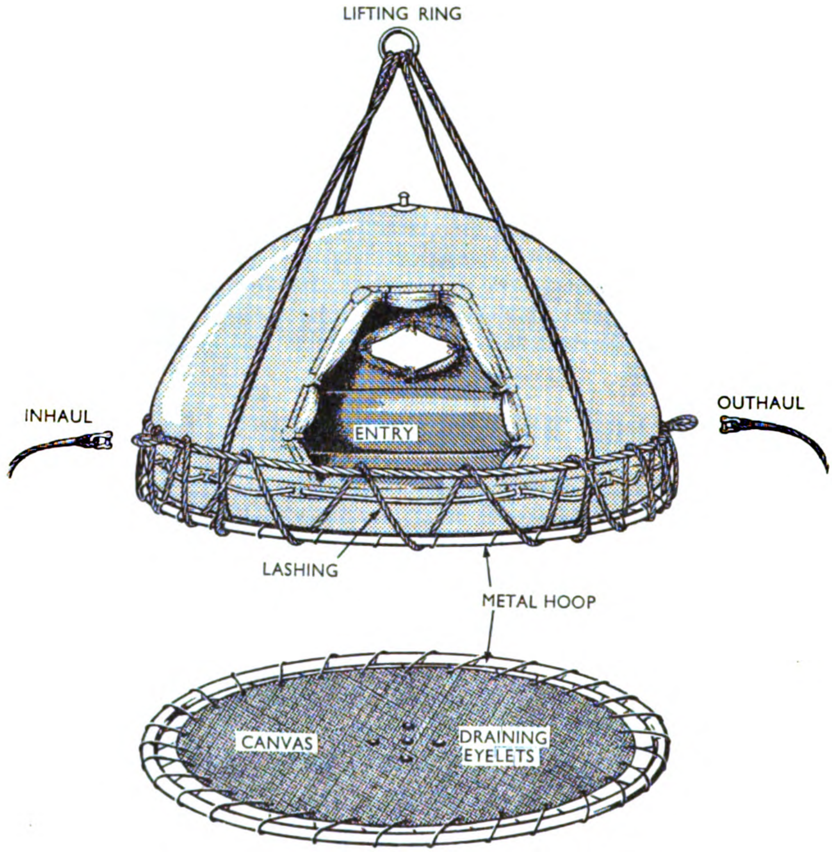


FIG. 11–17. Inflatable liferaft rigged for transfer

to the thimbles are the inhaul and outhaul, consisting of 120 fathoms of 2-in. manila. Two 3-in. manila lifting pendants passing under the raft are seized to the grommet, and the four ends are eye-spliced to a metal lifting ring so that they clear the crown of the canopy. This rig allows the raft to be lowered and hoisted empty, other than for an emergency, and to be hauled with its load between two ships by the inhaul and outhaul.

Liferaft to be hoisted with load. The normal rig should be modified as follows: Construct a metal hoop of 1½-in. piping, 12 in. less in diameter than the external diameter of the raft. Lace within the hoop a circular canvas cover fitted with the necessary metal grommets for taking the lacing and for the drain-holes (fig. 11–17). The raft is placed on top of the hoop, the hoop is lashed to the manila waist grommet, and the lifting pendants are then eye-spliced to the hoop.

Lowering and hoisting arrangements

It is an advantage to use a derrick which will plumb the raft on deck and swing it well clear of the ship's side. A derrick amidships will enable the ship

to give the raft a better lee and keep the inhaul and outhaul away from the propellers, which will be turning frequently to hold the ship in position. The derrick purchase should be a single whip of 3-in. manila or a tackle giving a similar safety factor. Leading blocks should be positioned on deck where needed for lowering or hoisting by power or hand.

When lowering, the raft is suspended from the purchase on a trip hook, which is replaced by a spring hook before hoisting. To lower the raft it is placed beneath the purchase, hoisted on the trip hook, swung outboard, lowered into the water, and released by pulling sharply on the trip hook rope. If the raft has not been loaded on deck it is held alongside by the inhaul and a jumping ladder or scramble net is provided.

METHODS OF TRANSFER

Normal transfer

The inhaul and outhaul are faked on deck for running, the raft is hooked on, hoisted, turned out, lowered to the gunwale and held in position by the inhaul and outhaul; and a gunline is made ready.

The supplying ship slowly approaches down-wind to the receiving ship, which is stopped, usually beam on to the wind. Passing close to the receiving ship's stern, she fires across the gunline, to which the outhaul is then bent (fig. 11–18(i)). The receiving ship hauls in the gunline and outhaul and the

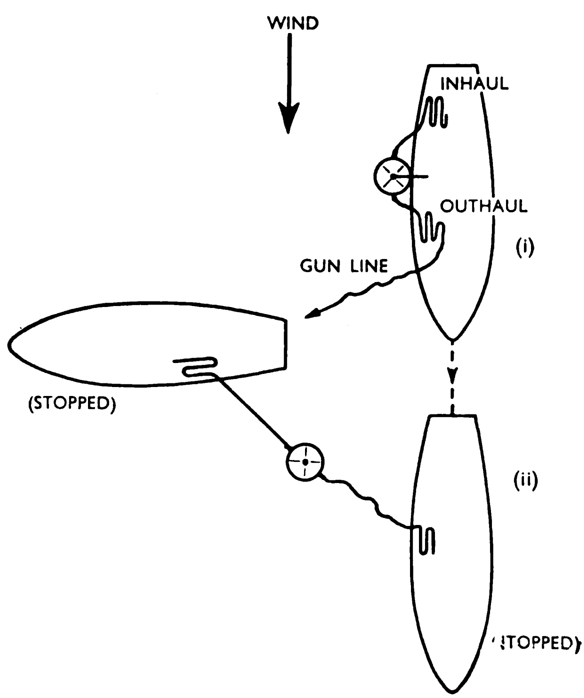


FIG. 11–18. Liferaft—normal transfer

supplying ship positions herself close to the receiving ship's stern, where she lowers and trips the raft. The transfer can now start between the two ships (fig. 11–18(ii)).

When the transfer is completed the receiving ship coils the outhaul and passes it to the crewman. The supplying ship hauls the raft back alongside and the crewman hooks on the lifting ring to the spring hook of the purchase. The raft can now be unloaded or, if the load does not exceed the authorised weight, hoisted on board.

This is the quickest and surest method, allowing several trips to be made, but it is very difficult for the supplying ship to maintain station, particularly when she has only one propeller, and there is always a danger of fouling the inhaul under the receiving ship's stern. Virtually no lee is provided for handling the raft alongside, and the ever-present risk of collision may make it necessary for the supplying ship to order violent engine movements when it is essential to keep the raft as steady as possible.

Outhaul transfer

This is the same as the 'normal' transfer, but only an outhaul is fitted to the raft, so that the supplying ship can steam clear as soon as the outhaul has been passed to the receiving ship and the raft has been released. When the transfer has been completed, the receiving ship places the outhaul in the raft and sets it adrift for the supplying ship to recover.

This method reduces the risk of collision between the two ships, but only one transfer can be made and there is a danger of losing sight of the raft in low visibility once it has been set adrift.

Free transfer

The supplying ship slips the raft at about one cable from the receiving ship's lee bow, draws clear and then stations herself ready to recover it. The receiving ship manoeuvres alongside the raft, unloads it and then sets it adrift. It has been found that the best approach course for recovery is down-wind, swinging across the wind to form a lee just before hooking on the raft.

This method is more suitable for bad weather conditions or when there is a risk of collision owing to the different drift-rates of the ships. However, it is much slower than the 'normal' transfer and there is always a risk of losing sight of the raft in reduced visibility.

In extreme weather conditions, if the transfer of stores is vital, rafts may be slipped without a crewman and set adrift for the receiving ship to retrieve by grappling or dropping a raft-jumper on board to secure the spring hook of the purchase to the lifting ring. This variation of the 'free' transfer avoids endangering life, but recovery of the raft is more difficult and sometimes impossible.

Hints to occupants of the raft

Rafts should normally be manned by a crew of one. Lifejackets, with light and whistle attached, must be worn by all personnel in the raft. Exposure suits must be worn in cold or rough weather.

Don't wear an open knife, boots, or clothes fitted with sharp buckles; but *do* wear a seaman's knife and stow it in the trouser pocket, and wear gloves in cold weather.

The crewman is to ensure that personnel or stores are evenly distributed in the raft during loading and unloading; otherwise the raft may capsize.

The crewman should carry a waterproof torch and, before shoving off, should check that the raft light is burning if the transfer is at night or in reduced visibility. He should keep the inside of the raft as dry as possible, and, if an outhaul has been used, see that it is all inside the raft before the supplying ship approaches. He should also see that the raft is lightened before it is hoisted, that the raft is fended off from either ship while alongside, and, when the raft is to be hoisted, that the spring hook is attached to the lifting ring as quickly as possible.

PART III

SHIP ORGANISATION

CHAPTER 12

Organisation

The officers and men of a ship must be organised in watches and divisions for working and fighting the ship, for the proper maintenance of her equipment and for the welfare of her company. Messes and berths must be allocated, feeding arrangements made and special parties nominated.

Ships vary considerably in size, armament, layout and manning standards, and they may operate in many different parts of the world and in varying climates, so the organisation may have to be changed to suit the ship and climate; however, the general principles of organisation are the same throughout the Royal Navy. The organisation described in this chapter is generally that required for a frigate, but the lists of special duties and special ratings include all those that may be found in larger ships other than aircraft carriers; in the latter, there are special parties for the operation of aircraft.

ON COMMISSIONING A SHIP

Schemes of complement

Every man-of-war has schemes of complement which show the number of officers and men required to man her under various conditions of war and peace; they also show the required specialist and sub-specialist qualifications of officers, and the numbers and required qualifications of every branch of rating. When a ship is due to commission or recommission a nominal list of all officers and men is obtained from the Director of Naval Officer Appointments and the Commodore of Naval Drafting respectively, from which certain 'bills' are compiled in the ship.

Watch and station bill

Each department produces a printed broadsheet ruled in columns which shows the ship's book number, name, watch, part of watch, sub-division (if any), stations and special duty (if any) of every man in the department. The stations usually include emergency station and liferaft or boat station. They may also include the 'quarters' of the armament to be manned at every degree of readiness. The watch and station bill for seamen also shows the part of ship.

Watch and quarter bill

In war, different circumstances require that the whole, or only a portion, of the armament of a warship be kept manned and ready for instant action. The manning of her armament is therefore based on the watch system, so that the whole or only a portion of the ship's company are at their quarters according to the degree of readiness required by the existing circumstances. There are four different degrees of readiness, under which all hands, a watch, two watches,

or a part of the watch are kept closed up at their action stations. A man's action station, or 'quarter', is that part of the armament of a ship to which he is detailed for fighting duties and it may vary with the degree of readiness for action which is in force. The watch and quarter bill shows the quarter allocated to each man for every degree of readiness. Certain ratings—for example, those of the Supply branch—have no quarters in the lower degrees of readiness when they must be able to continue with their normal ship duties.

A watch or part of a watch includes not only a balanced proportion of petty officers and men from each part of ship, but also a balanced proportion of the hands necessary for manning and fighting a portion of the armament.

DEPARTMENTS AND DIVISIONS

Officers and men are divided up in *departments* according to their specialisation, and these in turn form *divisions* or may be further sub-divided into more divisions, or combined, according to the numbers borne. The head of each department has direct access to the Captain concerning the work of his department; whereas the Seaman sub-specialist officers normally work under the direction of the First Lieutenant, but have direct access to the Captain on matters concerning their sub-specialisation.

Each department has its own organisation for cleaning the compartments and maintaining the equipment for which it is responsible, but all departments conform to the general routines of the ship agreed between the First Lieutenant and the other heads of departments. Thus the following paragraphs, which concern mainly the Seaman branch, have some application to all branches.

Traditional or functional organisation for seamen

The two methods are described briefly in Vol. I, and here it is intended to give some of the advantages and disadvantages of each.

The traditional, or part-of-ship, organisation has the advantages of mixing seamen of different specialisations, so that the divisional spirit prevents any tendency to exclusiveness and isolation of the specialist branches, and of spreading the effort equally between each part of ship when a part of the armament is being used. The disadvantages of this method are that the requirements of part of ship and armament quarters may conflict so that two officers are competing for the employment of the same hands: a man therefore may have a divisional officer who is not also the head of his branch; he may also have a different opposite number in his part of ship and at his armament quarter, and he may not be berthed near his quarter.

The functional organisation has the advantages of providing continuity when a ship has to change from a peace to a war organisation; divisional officers and petty officers work with their men in part of ship and at their quarters; there is no conflict between part of ship and armament duties, because they both come under the one divisional officer; a greater efficiency of branches is achieved because the same men work together regularly on deck, at action and in the mess; and it is easier to accommodate men near their quarters. The disadvantages are that it may lead to branch exclusiveness; and it tends to restrict

a man to one part of ship for a commission, although special duties (mentioned later) and evolutions carried out by a watch only should widen his experience.

Functional-traditional compromise. In practice it may not always be possible to adopt a functional organisation—for example, when seamen attached to the Weapons and Radio department form part of that division. By organising a division functionally for accommodation and traditionally for mixed part of ship, greater branch unity is achieved, but all (except the last) disadvantages of the traditional method remain.

ALLOCATION OF HANDS FOR WORK

Certain bugle calls or pipes are used to summon the whole or a part of the ship's company for normal or special work according to the number required.

'*Clear lower deck*'. Calls all men of all branches except those actually on watch. When the hands are required for manual tasks, such as boat-hoisting and the embarkation of stores, it is customary to qualify the call or pipe by 'Stand fast, Chief Petty Officers and Petty Officers'.

'*Both watches* (or *All watches*) *of the hands*'. Calls all seamen and marines except those actually on watch, and is used only when hands are required to fall in for some special purpose; normally they are piped to 'carry on with your work'.

'*Watch of the hands*' or '*Part of the watch of the hands*'. Calls all seamen and marines of the watch or part of the watch designated except those actually on watch.

'*Both watches for exercise*', '*Watch for exercise*', '*Part of the watch for exercise*' or '*Sub-division for exercise*'. Calls all the seamen and marines of the watches, watch, part of the watch or sub of the watch (as designated), except those on watch, those in training classes and those on the 'excused list' (described later).

'*Hands working on the upper deck*'. Calls a limited number from their work when a small number of hands is required unexpectedly.

'*Two hands each part of ship*'. Calls a small fixed number of hands for unexpected work.

'*Duty hands*'. A few duty hands from the duty watch or duty part of the watch can be called for small jobs out of working hours.

SPECIAL DUTYMEN AND SPECIAL PARTIES

There are many special duties of a standing nature in a man-of-war for which men are detailed individually or in special parties. Men so detailed are known as 'special dutymen' and work to a special routine; they are excused many of the routine musters and general ship work, but carry out their watch duties with the remainder of their watch or part of the watch.

Excused list

If these special dutymen and special parties were excused all general ship's duties there would be insufficient hands available to work the ship. They are therefore listed in the 'Excused List', which is prominently displayed and shows

exactly which musters and general ship's duties each is excused and which they are to attend or take part in.

Special dutymen

Messengers. These special dutymen are detailed from ordinary and junior seamen. They may work to a daily routine or by watches, and are allocated to the Captain, Commander, Officer of the Watch, certain other officers and various offices in the ship. Office messengers clean out their offices when the hands turn to in the morning.

Messmen. Seamen and engine-room ratings are detailed as messmen to chief petty officers' and petty officers' messes. They are responsible for keeping their messes clean and for serving meals in the messes in ships without cafeteria messing.

Ship's butcher. This duty is carried out by a specially qualified seaman or marine who works under the orders of the Supply Officer.

Sweepers. All departments provide their share of sweepers to clean flats, heads, passages and compartments between decks that are used by everyone, working under the orders of the messdeck petty officer. Flats adjacent to offices and store-rooms are usually cleaned by the department occupying the office or responsible for the store-room.

In some ships the duty hands or a special night cleaning party clean the main passages in silent hours; in others all available hands from all departments go to 'cleaning stations' for an hour at the start of the day's work and thereby get most of the cleaning done in that time, but some permanent sweepers are usually required.

Special parties

Boatswain's party. A small party of seamen, including the Boatswain's Yeoman and usually under the charge of a petty officer or leading seaman, works under the Boatswain or Chief Boatswain's Mate. It is responsible for the cleanliness and condition of gear in the boatswain's store and for canvas and rope gear not issued to parts of ship. It also carries out repairs to rigging.

Daily user check parties. Selected ratings are required to close up at their action stations daily to check the performance of their equipment. This is usually done early in the day to ensure that all equipment is working satisfactorily and at peak performance; defects are brought to light and reported to the Weapons and Radio party; the user takes a personal interest in his equipment and remains familiar with its use and operation; and the more skilled ratings in the Weapons and Radio party are released from simple daily checks to carry out maintenance and repairs.

Gunner's party. A party of seamen and marines, including the Gunner's Yeoman, work under the Gunner to keep all the armament spaces and store-rooms for which the Gunner is responsible in a clean and efficient condition.

Heads party. The ship's company heads are kept clean and in good order by a mixed party of various branches and marines, under the charge of a seaman rating known as the 'captain of the heads'. The party may be included in the organisation for sweepers.

Laundry party. The ship's laundry is worked by a mixed party from various branches under the charge of a senior rating trained in laundry work. In some ships the laundry is operated by engine-room ratings assisted by seamen.

Shipwright's party. This party consists of seamen or engine-room ratings who work as mates to the shipwrights.

Side party. A party of seamen working under the 'captain of the side' (a petty officer or leading seaman) who are responsible for cleaning and touching up the ship's side and painting the cable between the hawsepipe and waterline or buoy; they are also responsible for the disposal of 'gash' and working the incinerator.

General Mess party. One or more hands from any department (under the charge of a petty officer or leading seaman known as the 'captain of the hold', where the size of the party warrants), who work under the orders of the Supply Officer. Their duties include the correct and secure stowage of the contents of the provision rooms, cleanliness of these spaces and bringing up provisions daily to meet the requirements of the General Mess. They may be required to assist in food preparation in the main galley.

Naval stores party. One or more hands from any department who work under the Supply Officer on the cleanliness of store-rooms and the proper stowage of their contents.

Dining-hall party. A party drawn from all departments who lay tables, wash up and clean the ship's company dining-hall. They work under the orders of the Executive or Supply Officer, whichever has responsibility for the dining-hall.

'Tweendeck party. Some ships form a permanent Hull/Ventilation/NBCD ('tweendeck) party of mixed branches under the Shipwright's direction to keep equipment serviced and repaired and markings up to date. They are more versatile than the purely NBCD party and form a knowledgeable backbone to the damage control parties.

Weapons Radio party. Certain seamen with particular specialist qualifications are attached to the Weapons Radio party, under the Weapons Radio Officer, for maintenance and repair of the armament.

Other parties

Several other parties or individuals have special duties that occupy them for some or all of the working hours. They are: barge's crew, boat party, cabin hands, departmental officers' writers, liferaft party, Navigating Officer's yeoman, sailmaker and watchkeepers (described later).

Communal duties

All departments are required to undertake communal duties in proportion to the number of Able ratings and below allowed, so that work to be undertaken outside normal working hours and certain domestic chores are shared as evenly as possible. Communal duties may therefore include landing parties, storing parties, patrols and guards (where no Royal Marine detachment is borne), and the dining-hall party (see above).

No man should spend more than 4 months out of 18 on communal duties, nor should they interfere with his technical duties or his prospect of advancement.

SPECIAL DUTYMEN AND SPECIAL PARTIES FOR OCCASIONAL DUTY

In addition to the standing special dutymen there are other special dutymen and special parties who are required for occasional duties. The more important of these are given below.

Special sea dutymen

This is a standing party of petty officers and men of various branches who man the navigating control positions when the ship is entering or leaving harbour. When the ship is clear of the harbour they are relieved by the sea dutymen of the watch on deck. Some or all of those listed below will be needed, according to the size of the ship.

Name	*Position of duty*
Chief Quartermaster or Coxswain	at the wheel
Quartermaster of the watch and telegraphsmen	in the forward steering position
Quartermaster longest off watch	in the after steering position
Leadsmen	on deck abreast the bridge
Speed flagmen	on the bridge
Screw flagmen	aft (visible from bridge)
Boatswain's mate of the watch and bugler of the watch	at the forward broadcaster
Telephone operators	on the forecastle, quarterdeck and bridge
Captain's coxswain and messenger	on the bridge
Bridge messenger	on the bridge
Radar operators	as required
Navigating Officer's yeoman	on the bridge (keeps record of wheel and engine orders)
Chief Boatswain's mate	with Commander or First Lieutenant

Cable party

A standing cable party is usually detailed from each watch to work the cables when the ship comes to an anchor, weighs, moors, unmoors, or makes fast to, or slips from, a buoy. It consists of a petty officer (1st or 2nd captain of forecastle), a number of seamen, a P.O.M.(E) or Electrical artificer, a shipwright and one Electrical and one Communication rating.

Patrols

In many ports it may be necessary to land a patrol to maintain good order and naval discipline among libertymen ashore, and to ensure their safe disembarkation and embarkation from and into ship's boats. The patrol is provided from the watch on board under the charge of a petty officer. They wear gaiters, belts and patrol armlets, and are empowered to arrest any naval rating.

Guard

In ships which carry enough Royal Marines the 'guard' is provided from the R.M. detachment for the ceremony of Colours and for the reception of senior officers. The guard also provides sentries for such posts as the Admiral's or Captain's cabin, Important and Armament keyboards and pistol rack, cells, forecastle and jetty.

In ships with too few or no Royal Marines, guard duties are undertaken by other departments under the charge of a petty officer, and certain sentry posts are filled by seamen when required.

PETTY OFFICERS' SPECIAL DUTIES

Duty petty officer

In a small ship he is a seaman petty officer whose duties include calling the hands in the morning, mustering men under punishment and supervising their work and drill, mustering and checking libertymen and the duty watch, taking offenders before the Officer of the Day, reporting for evening rounds in the absence of the Coxswain, closing of senior ratings' beer bars and carrying out rounds in the middle and morning watches.

Petty officer of the day

In a small ship he is one of the petty officers not included in any other duty roster. He attends all issues of spirit. He supervises in the dining-hall during meal hours and at the issue of beer to junior ratings and assists the duty petty officer when required.

Duty regulating petty officer

In a large ship he is a seaman petty officer. He calls the hands in the morning, musters and checks libertymen, goes rounds between decks after the return of the last liberty boat, closes officers' messes at the regulation hours, takes offenders after working hours before the Officer of the Watch, is responsible to the Master-at-Arms for any cell offenders, reports evening rounds in the absence of the Master-at-Arms, and assists generally in regulating duties.

Duty messdeck petty officer

A seaman petty officer who supervises the messdecks, flats and bathrooms after working hours, and sees that they are cleared up at the regulation times.

Duty gunnery instructor

In a large ship he goes the rounds in compartments adjacent to magazines, once in each watch except between 2000 and 0800, when these rounds are carried out by an officer. He is responsible to the Officer of the Watch for covering and uncovering the ship's armament and its general security. In small ships he may also take his turn as duty petty officer.

Duty juniors' instructor

Out of working hours he is in general charge of junior ratings to see that they

turn out at the right time and that their messdeck is kept clean and tidy. If insufficient juniors' instructors are borne, these duties may be carried out by other duty petty officers or leading hands.

PETTY OFFICERS' PERMANENT DUTIES

Chief Boatswain's Mate

A chief petty officer or senior petty officer of the Seaman Branch assists the Boatswain in taking general charge of, and maintaining, all upper deck gear, rigging and stores. When no Boatswain is borne he carries out that officer's duties. He takes charge of all main musters of the hands and watches (except clear lower deck, divisions and evening quarters), and reports them to the Executive Officer or his deputy. He personally assists the Executive Officer and the Boatswain in the general working of the ship and at drills and evolutions.

Captains of tops

A senior petty officer of the Seaman Branch is allocated from each watch to take charge of each part of ship. At main musters they report their part-of-ship hands to the Chief Boatswain's Mate.

Messdeck petty officer

A chief petty officer or senior petty officer of the Seaman Branch is placed in general charge of the messdecks, flats, heads and bathrooms and is responsible to the Messdeck Officer for the cleanliness and upkeep of all living spaces.

Captain of the side

A seaman petty officer (or leading seaman) takes charge of the seamen in the side party.

Physical and recreational training instructors

These are specially qualified chief petty officers, petty officers or leading seamen who instruct the ship's company in physical and recreational training. They are in charge of all sports gear, and assist the Sports Officer in arranging all sports and recreation. They may also be detailed for duty as juniors' instructors and to assist with instruction in seamanship.

Admiral's and Captain's coxswains

Chief petty officers or petty officers who are coxswains of the Admiral's barge and Captain's boat and, in harbour, take charge of the work of their boats' crews as directed by the Flag Lieutenant and Captain. They attend on the Admiral and Captain when the ship is entering or leaving harbour and on other occasions at sea when required.

WATCH ORGANISATION

Depending upon their size and general arrangements, ships' companies work in two-, three-, or four-duty watches, or sometimes part of the ship's company works under one system and part under another. At sea the duty part of the watch changes at the end of each watch, i.e. every four hours (two hours in the dog watches), but in harbour the duty part changes every 24 hours only, at 1230.

Whichever watch system is adopted it is convenient to maintain a regular sequence of watches, and for this a roster is useful. An example of a roster which caters for each system is given on page 422. It may be memorised if it is noted that:

1. If the ship proceeds to sea and so changes the duty watch every 4 hours instead of every 24, the duty part in harbour has the afternoon watch at sea.
2. Conversely, it the ship returns to harbour, the party detailed for the afternoon watch at sea becomes the duty part for that day in harbour.
3. The sequence for coloured watches, both at sea and in harbour, is red, white and blue.
4. The sequence for parts of the watch at sea is 1st of port, 1st of starboard, 2nd of port, and 2nd of starboard; whereas in harbour it is 1st of starboard, 1st of port, 2nd of starboard and 2nd of port (see the Afternoon Watch column).

Long watches of six hours may be arranged in some ships, so that the night hours are divided into two, i.e. 2000–0200 and 0200–0800.

Staggered times of changing watches. It is obviously undesirable, particular in time of war, for the whole ship's company to be in the throes of changing watch at the same time, and this can be overcome by arranging departmentally a plan of staggered times for changing watches.

WATCH DUTIES IN HARBOUR

Out of working hours and excluding the duties described under 'Watch-keepers', on page 423, the 'watch on board', and more particularly its duty part, must be ready at all times to turn to for any work or to deal with any emergency which may arise. In addition, the duty part provides special parties for certain routine or special duties. Some of these special parties may be required to sleep in special billets where they can be called quickly in an emergency. The hands for each party are detailed either by the petty officer in charge of the duty part of the watch or in daily orders.

Fire party

This party includes men of all branches from the duty part of the watch competent to deal with an outbreak of fire. It is under the charge of a petty officer and its size depends on the size and class of ship.

Damage control party

This party is also selected from the duty part of the watch and is responsible for seeing that the ship is maintained at the required state of readiness by constant patrolling in silent hours.

DUTY WATCH ROSTER

	Middle	Morning	Fore-noon	After-noon	First Dog	Last Dog	First
Aug. 24, Sept. 5 ..	1 P Red	1 S White	2 P Blue	2 S Red	1 P White	1 S Blue	2 P Red
Aug. 25, Sept. 6 ..	2 S White	1 P Blue	1 S Red	2 P White	2 S Blue	1 P Red	1 S White
Aug. 26, Sept. 7 ..	2 P Blue	2 S Red	1 P White	1 S Blue	2 P Red	2 S White	1 P Blue
Aug. 27, Sept. 8 ..	1 S Red	2 P White	2 S Blue	1 P Red	1 S White	2 P Blue	2 S Red
Aug. 28, Sept. 9 ..	1 P White	1 S Blue	2 P Red	2 S White	1 P Blue	1 S Red	2 P White
Aug. 29, Sept. 10 ..	2 S Blue	1 P Red	1 S White	2 P Blue	2 S Red	1 P White	1 S Blue
Aug. 30, Sept. 11 ..	2 P Red	2 S White	1 P Blue	1 S Red	2 P White	2 S Blue	1 P Red
Aug. 31, Sept. 12 ..	1 S White	2 P Blue	2 S Red	1 P White	1 S Blue	2 P Red	2 S White
Sept. 1, Sept. 13 ..	1 P Blue	1 S Red	2 P White	2 S Blue	1 P Red	1 S White	2 P Blue
Sept. 2, Sept. 14 ..	2 S Red	1 P White	1 S Blue	2 P Red	2 S White	1 P Blue	1 S Red
Sept. 3, Sept. 15 ..	2 P White	2 S Blue	1 P Red	1 S White	2 P Blue	2 S Red	1 P White
Sept. 4, Sept. 16 ..	1 S Blue	2 P Red	2 S White	1 P Blue	1 S Red	2 P White	2 S Blue

Night boat's crew and lowerers

Out of working hours a boat is kept ready for immediate use in an emergency. The crew is usually one of the boat's crews manned by watchkeepers, and the lowerers are detailed from the duty part of the watch.

Emergency party

In small ships the emergency party comprises the whole of the duty part of the watch; in larger ships it is a part of the duty part of the watch and may be required to sleep in special billets.

Anchor watch

In heavy weather, or when the ship is anchored in an exposed roadstead or in a strong tideway, an anchor watch is 'set', i.e. detailed, to watch the cable,

veer or heave it in, let go a second anchor, slip the cable, or weigh anchor, as may be necessary. An anchor watch usually includes two or more seamen, a P.O.M.(E), a shipwright, an electrician and a signalman, all under the charge of a seaman petty officer: a quartermaster and telegraphsman are also detailed if the engines are at immediate notice. The anchor watch is backed up by the cable party of the watch or part, as necessary.

WATCHKEEPERS

There are some duties which require a continuous watch and those carrying out these duties are known as 'watchkeepers', who have a special routine for work, recreation, liberty and leave. Watchkeepers usually work in four watches, are allowed to lie in until 'Up guard and steerage' and are granted liberty out of normal routine times. It is customary for watchkeepers to return on board at least four hours before they are due to go on watch.

The following watchkeepers are provided mainly by the Seaman Branch.

Navigation party

Quartermasters, boatswain's mates and corporals of the watch form the navigation party (gangway staff) and usually work in four watches. The party is supervised by the quartermaster, who is responsible to the Officer of the Watch or Officer of the Day for running the routine, guarding the gangways, and keeping watch on the general safety of the ship and her boats.

Boat's crews

Boats which are required to run day and night are provided with two crews, one from each watch. These crews work 24 hours on and 24 hours off duty, and usually relieve each other at 1230. The stand-off crew work with their parts of ship in the forenoon, and both crews join up with their parts of ship on going to sea.

WATCH DUTIES AT SEA

At sea it is usual for all hands to be 'on deck', i.e. available for duty, and to work the normal daily routine from the time of 'hands fall in' to the end of working hours; and men are detailed from the watch on deck or duty part for specific watchkeeping duties and tricks. After working hours the first dog watchmen (or the afternoon watchmen on make and mend days) take over the watch on deck, and the watch system in force is then continued until the time of 'hands fall in' on the following morning.

Men are detailed from the watch or part of the watch on deck by the petty officer in charge, for the following special duties.

Seaboat's crew and lowerers

Owing to shortage of hands on deck, the seaboat's crew and lowerers may have to be detailed from the crews of the operations room and sonar control room.

Swimmer of the watch

Often the quickest way of recovering a man overboard is by swimmer. In each watch a strong swimmer, trained in lifesaving, should be available for this task. He should wear flippers, and in cold water a shallow-water diving suit.

Lookouts

Lookouts work in tricks of one hour, or less in time of war. In peace one lookout only may be closed up on the bridge during daylight and two at night; in fog or bad visibility the number may be increased to include masthead and forecastle lookouts. In war and in exercises the number of lookouts is considerably increased and varies with the function of the ship; special air, anti-submarine and helicopter lookouts may be required.

Bridge messenger

A junior seaman is detailed for the duration of the watch and works under the orders of the Officer of the Watch.

Seaman gunner of the watch

The seaman detailed for this duty provides pyrotechnics (i.e. fireworks and grenades) and line-throwing gear when needed.

Helmsman and telegraphsman

A helmsman is detailed to steer the ship for a trick usually of one or two hours' duration, and a telegraphsman is detailed to work the engine room telegraphs for the duration of the watch. Both work under the supervision of the Quartermaster.

Leadsman

A leadsman is detailed only when required.

EVOLUTIONS

In addition to her normal tasks, a ship must be prepared to deal immediately and efficiently with any emergency or eventuality which may come her way. It would not be possible to issue detailed orders to meet every situation which might arise, but it is possible to issue orders for some duties or emergencies which it is known from past experience are likely to be encountered; these are known generally as 'evolutions'.

Each evolution requires a certain number of men for its efficient execution in the shortest possible time; if too many men are detailed they will hamper each other's work, and if too few the evolution will take longer to complete, or may even be impossible to execute. It is therefore usual to make out stations for evolutions on the watch system, employing a sub-division, a part of watch, a watch, or all watches, according to the nature of the evolution, and to apportion the provision and working of the necessary gear among the parts of ship in the watch or part of the watch concerned.

Ammunition ship

Embarking or disembarking ammunition is an important operation which usually involves the whole complement of seamen and Royal Marines. It requires careful planning and organisation, and, because of the dangerous nature of the work, certain precautions must be taken while work is in progress. Regulations for ammunitioning are given in several books, but the more important are summarised below.

1. Only whips, tackles and other equipment specially provided for the purpose are to be used.
2. All gear must be inspected before and after use.
3. No smoking is allowed.
4. Radio emissions are strictly controlled.
5. Normally ammunitioning is stopped during wet weather or thunderstorms.
6. Gasoline and paraffin may not be embarked or disembarked at the same time as ammunition.

Air bedding

Weather permitting, the bedding of the ship's company should be aired regularly. It is hung over the guardrails or triced to gantlines on which each division is allotted space. Care must be taken to stop each set of bedding securely and close to the next set so that there are no holidays.

Dress ship

Ships are dressed overall on certain anniversaries of national importance when in harbour. There must therefore be an organisation for manning the dressing lines and downhauls and for stationing men at positions where the dressing lines may snag in upperworks.

Landing parties

These parties consist mainly of seamen, engine-room ratings, electrical ratings and marines, with a small proportion of officers and men from other branches. They are organised in platoons, which, together with those from other ships, may be formed into companies and battalions. Each ship carries sufficient small arms and minor weapons to arm its landing party so as to assist in internal security ashore.

Man ship

Manning ship is a ceremonial mark of respect carried out on special occasions. The ship's company is stationed at close intervals along the weather decks and superstructures, about one pace clear of the guardrails, thus forming an unbroken line of men on each side throughout the length of the ship.

Out anchor

In some ships a bower anchor and killick, in others a killick only, can be taken away from the ship by boat and laid to provide a means of hauling the ship out from her berth if there is a lack of manoeuvring space; to keep the ship pointed

in a certain direction or to keep her from swinging to wind or tide when at anchor; or to haul the ship off a shoal or clear of some navigational danger.

These evolutions are described in Chapter 10.

Paint ship

Painting the ship's hull and upperworks is a major task that requires all seamen and marines, with other departments assisting (e.g. the Weapons and Radio department paints part of the radar aerial arrays). It must be done quickly so as to take advantage of good weather, and therefore careful and detailed preparations must be made. Preparations include:

1. cleaning, derusting, priming and washing the ship's side,
2. rigging painting stages and obtaining catamarans,
3. mixing sufficient paint for the job in one large tub,
4. provision of pots, brushes, rollers, sprayers and an air supply,
5. arrangements for tending stages, replenishing pots, reliefs for meals, etc.

Preparation for sea

Before proceeding to sea a ship must be prepared so that everything is working properly and all gear is properly secured. This preparation includes: equipping and rigging seaboat(s); testing main engines, steering gear, sirens, sea communications, radar and compasses; singling up berthing hawsers, if alongside; reeving sliprope and preparing to unshackle the bridle, if at a buoy; shortening in cable, if at single anchor; unmooring, if moored; setting up guardrails and rigging lifelines; covering and securing all movable gear; and assuming the correct Damage Control state and condition.

The Executive, Marine and Electrical Engineer Officers each report to the Captain when their department is ready for sea.

Replenishment in harbour

A ship must replenish her naval stores at two- to four-monthly intervals depending on her type, and her provisions at intervals of one or two months depending on her stowage capacity, unless she has replenished at sea. The chief requirement is to ensure a free flow of stores from the jetty, store ship or lighters to dumps on the weather decks and thence to the store and provision rooms.

The preparations vary in different classes of ship and depend also on whether dockyard equipment is available when the ship is alongside and whether cranes can be used. Normal preparations include the rigging of derricks, siting the dumps, providing barrows, opening doors and hatches, rigging whips, tackles and canvas chutes, and organising traffic routes.

Sentries may be needed if store dumps have to be left unattended.

Darken and undarken ship

In war and during fleet exercises a ship is darkened at dusk and undarkened at dawn, as ordered by the Captain or the Officer of the Watch. Stations for darkening ship must be organised in detail to ensure that no scuttle or aperture is missed through which artificial light can be seen from outboard.

Entering or leaving harbour

When a ship enters or leaves a harbour the ship's company is fallen in by divisions on the weather decks. On these occasions the ship and her company are critically watched, not only by other warships, but by merchantmen, longshoremen and civilians. The ship should therefore look as smart as possible and particular care should be taken that every one is correctly dressed in the 'rig of the day', that scuttles and weather doors are closed and no one looking out of them, and that everything is ship-shape.

Prepare for towing

When at sea a ship should always be prepared to tow or be taken in tow at short notice. Either evolution may have to be carried out from either end of the ship, and stations must be organised accordingly. Preparations for towing are described in Chapter 10.

Replenishment at sea

A ship must be prepared to embark or disembark men, fuel, stores and ammunition from or to ships and helicopters while at sea. The standard methods of transfer between ships are given in Chapter 11.

DAILY ORDERS AND OFFICES

Particulars of the work and duties of the ship's company, especially of those of the Seaman Branch, are published and issued by the Commander's (or First Lieutenant's) office as 'Daily Orders', usually the evening before they are to be carried out. These orders include the names of officers and men detailed for routine duties, also any orders or instructions required for duties of a non-routine nature. They are posted on the messdeck and other notice boards and must be read by everyone.

In small ships there is a Central Routines office which co-ordinates the requirements of all departments and produces the Daily Orders; a Daily Order Book being kept for departments to insert their special requirements for the following day.

Offices

The general organisation and administration of a man-of-war is directed through several offices according to the size and function of the ship, so that some or all of the following offices may be found.

Captain's office. This office deals with questions of general policy in the administration of the ship and with records and documents relating to all her officers and men. All official correspondence for the Commanding Officer is delivered to and sent from this office, and it is the collection and distribution centre for 'D.S.B.' or Fleet orderly correspondence.

Commander's office. In larger ships this office administers the internal organisation of the ship and is responsible for the issue of routines, Daily Orders and similar matters.

Central Routines office. In small ships this office co-ordinates the requirements of all departments for the production of Daily Orders.

Regulating or Coxswain's office. All matters of discipline, liberty and leave of the ship's company, the 'checking' of officers and men in and out of the ship and the daily calculation and recording of numbers entitled to the spirit ration are dealt with in this office. The coxswain's office in a small ship usually handles Post Office mail.

Pay office. The pay accounts of all officers and men in a ship are kept in the ship's ledgers; in small ships not carrying their own pay accounts the ledgers will be kept at the accounting base and the ship's office will hold pay lists. All public money transactions, such as pay allotments, remittances and the sale of postal orders, are made in this office.

Victualling office. This is the administrative office for the victualling of officers and men, the issue and replenishment of provisions and clothing, and the messing of the ship's company.

Naval Stores office. This office is concerned with the accounting, stowage, issue, return and replenishment of naval stores except those issued separately to the Boatswain and Gunner and the technical departments.

Technical office. This is usually the combined office of the Marine and Electrical Engineers, from which their departments are administered and organised for working, maintenance and repair.

Main signal office. This office organises and controls the despatch, receipt, routeing and internal distribution of all communications other than mail.

Mail office. This office handles the despatch, receipt, collection and internal distribution of all Post Office mail. In small ships this is included in the duties of the Coxswain's office.

MESSING, PROVISIONS AND STORES

MESSING

(Reference: B.R. 93, *Victualling Manual*, Chapter 4)

General messing

Most ships are messed on the General Messing system. Under this system the Supply Officer is allowed to spend up to an authorised daily monetary allowance for each victualled member of the ship's company plus an additional allowance for each junior. He provides four meals a day, viz. breakfast, dinner, tea and supper (a high tea and late snack). Much of the food is supplied by the Victualling Yards and the Supply Officer charges this against the allowances at standardised Fleet issuing prices. Supplementary supplies purchased from NAAFI or from local traders are charged at cost. The meals are designed to provide an adequate standard of dietary for the particular conditions and the menus are varied as much as possible. Normally a range of choices is offered at the main meals.

The organisation for serving meals under the General Messing system

depends on the design of the ship and the facilities available. There are three variants:

Centralised general messing. This is the arrangement in all the more modern ships. The food is served to each man individually, in most cases on a self-help basis. He eats it in an adjoining central dining-room which is quite separate from the living accommodation. The washing-up is done by a special working party.

Modified centralised general messing. In some ships where it has not been possible to provide a central dining-hall the men are served individually at the galley servery, and they eat the meals in their living accommodation.

Broadside general messing. This arrangement applies in the much older ships. There is a central galley and the food is drawn in bulk from it by duty hands from each mess and served out in the mess spaces. The system involves unavoidable wastage and, to cover this, the messing allowances for broadside messes are increased by a special supplement.

Victualling allowance messing

This system is used in small ships which do not have suitable space or sufficient staff to operate any kind of general mess. Under the system, each mess is fully responsible for its own catering and a sum of money equivalent to the victualling allowance for the mess is advanced to the Commanding Officer. All provisions drawn by the mess, whether from Service, from NAAFI, or private traders, are paid for in cash at the time of supply. If at the end of the month, the victualling allowance has been underspent, 'mess savings' are paid to the men; if it has been overspent, recovery of the excess expenditure from the members of the mess is necessary.

Most officers' messes use a similar system. They may, however, opt to be victualled from the general mess and, in very small craft, officers and men do sometimes form one mess for victualling purposes.

Action messing

This is an emergency system designed for conditions when normal messing cannot be worked, e.g. when the ship is at a high state of readiness, at shelter stations, or for the NBCD reasons. There are two variants, A and B.

Variant A is used in circumstances when it is possible to release a part of the ship's company at a time to have a cooked meal in a mess. Not more than 20 per cent are released at once. Each man goes to the mess to which he has been allocated for emergency feeding, eats his meal and returns promptly to his action station so that the next man can be released. The procedure is continued (the state of readiness permitting) until the whole of the ship's company has been fed.

Variant B is used when the state of readiness makes it necessary for the ship's company to stand fast at their stations, or when the main cooking equipment is not available, or when access to messes is not possible. The ship's company is split into groups of convenient size. Emergency meals, such as meat pasties, pies, boiled eggs, fresh fruit, etc., are collected from emergency cooking positions by carriers detailed by each action mess group and distributed by them to the personnel at their action stations.

Extra issues

Various issues, extra to normal messing, are authorised to meet special conditions. There are two kinds: extras to meet a *medical* need; and extras to meet especially arduous conditions or work. Examples are:

Medical—lemon and orange powder in tropical climates, on the authority of the Medical Officer;

Arduous—a special messing supplement of extra food for men undergoing especially exhausting training.

PROVISIONS

(Reference: B.R. 93, *Victualling Manual*, Chapters 2 and 4)

'Provisions' is the name generally used in the Royal Navy for all food and drink.

Provisions on repayment

Service provisions may be purchased by general messes, at the standard Fleet issuing prices, under the following conditions:

1. Issues are to be made in bulk to the messes or groups and not to individuals
2. The provisions are not to be landed.
3. The issues are normally to be limited to items like tea, coffee, sugar, milk, lemon and orange powder for consumption outside normal meal times.

If, exceptionally, the Commanding Officer considers that these repayment issues would unduly reduce the stocks held on board he may restrict them pending stock replenishment.

Routine for issues

The routine for issuing provisions varies from ship to ship, but the following table can be taken as typical:

Time	*Issue, etc.*
0700 (in harbour)	Receipt and issue of fresh milk
0800	Issues from cold room
0830	Cutting up and issuing of meat
0930	Issue of all dry provisions to the galley to meet the menu for the 24 hours from tea-time on the day of issue
0930	Issue of fruit and vegetables for preparation in the galley
1100	Up spirits
1150	Grog issue
1245	Repayment issues of tea, sugar, milk, etc.
1315	Restocking of issue room from holds. Cleaning of store-rooms and implements
1530	Daily issues (bread, milk, etc.) to messes
1545	Extra issues
1700	Cold room opened; meat for next day removed for thawing out overnight

Stocks maintained

Fresh and frozen provisions. Stocks maintained are governed by the open and temperature-controlled storage available and the keeping qualities of the items.

Dry provisions. Stocks are not allowed to fall below the amounts required for 30 days' average consumption in cruisers and above, and for 15 days' average consumption in smaller ships. To ensure this, maximum stocks are embarked to a limit of 90 days' average expenditure.

Included in the above, a reserve for 14 days is held on board in the form of potato substitutes, tinned vegetables, fruits, tomatoes, meats, fish, baked beans and rice.

Methods of packaging

Provisions are supplied in packages of the following types:

Wooden and fibreboard cases, for tinned items

Hessian or multiwall paper sacks, for bagged items

Casks, jars, bottles or drums, for liquids; bottles are over-packed in wooden or fibreboard cases.

NAVAL AND AIR STORES

(Reference: B.R. 4, *Naval Storekeeping Manual*)

The term 'naval stores' embraces all standard stores (except armament stores) which are issued for general use throughout the Royal Navy. Such stores are detailed in a book known as the *Catalogue of Naval Stores*, and they are on charge to the ship's Supply Officer—except in small ships with no Supply Officer, where they are in charge to various departmental officers such as the Engineer Officer, Gunner and Boatswain.

The term 'air stores' embraces those stores peculiar to aircraft use and are similarly on charge to the Supply Officer.

Exceptions to the above are fuels, which are on charge to the Engineer Officer, and paint and timber, which are on charge to the Shipwright Officer if one is borne, or otherwise, also to the Engineer Officer.

All naval and air stores are classed as either 'permanent' or 'consumable'.

Permanent stores

The quantity of permanent naval stores of each type carried in a ship is detailed in a document known as the 'Allowance List'. Those for air stores are detailed in special lists prepared on the basis of the types of aircraft to be supported.

Permanent stores are drawn, on temporary or permanent loan, as required by each department of the ship, and if worn out or unserviceable they are normally returned to a dockyard for replacement: exceptionally they may be jettisoned.

Consumable stores

The quantity of consumable naval (and air) stores carried is based on previous expenditure. They are drawn by each Department as required for use and generally have no value (except as arisings) when they have been consumed.

STOWAGE OF STORES AND PROVISIONS

(References: B.R. 4, *Naval Storekeeping Manual*, Chapter 17; B.R. 93, *Victualling Manual*, Chapters 3 & 7 and Appendix 7)

Naval stores and provisions are stowed in store-rooms and provision rooms, each of which is designed to accommodate a particular type or class. These rooms are distinguished from each other by name and/or number, examples being: No. 1 Flour Room, Spirit Room, No. 2 Naval Store, Cool Room, Clothing (or 'Slop') Room, Emergency Provision Room, Beef Screen, Potato Locker, and Issue Room. Some rooms, such as flour rooms, are provided with a ventilation system, and those not so provided can be ventilated when necessary by portable hoses from a nearby permanent ventilation system. Special stowages are provided for heavy items, and many rooms, particularly those for stores, are equipped with racks and battens.

The chief requirements for the efficient stowage of stores and provisions are that:

1. Every package should be securely stowed so that it will not shift in a seaway.
2. Wherever possible, nothing should be in direct contact with the deck, bulkheads, ship's side or deckhead, in order to avoid damage from the moisture which frequently collects on these surfaces.
3. They should, where possible, be stowed so as to allow a free flow of air around them.
4. Sufficient space should be left between them and the bulkheads, or ship's side, to allow access for repair or firefighting.
5. Store and provision rooms should be adequately ventilated to prevent the air from becoming damp and depositing moisture; this is particularly important in the stowage of canvas, cordage, flour and other substances similarly susceptible to damage by moisture.
6. Store and provision rooms should always be kept clean and dry.

Stowage of inflammable liquids

Gasoline and paraffin may only be stored in special tanks, or in special cans in racks on the upper deck where they can be readily jettisoned in an emergency. All other inflammable liquids may only be stowed in special rooms which can be rapidly flooded or sprayed in the event of fire; these are the Inflammable Store, the Spirit Room and the Paint Store. All casks containing inflammable liquids (except rum) are labelled with pink labels marked INFLAMMABLE.

All the precautionary measures to be observed in the stowage of stores are contained in B.R. 4, *Naval Storekeeping Manual*.

Other special stowage requirements

Flour, sugar, tea and other provisions are all very susceptible to vapour, and so are easily flavoured by oil or other noxious fumes; for this reason no oil tank below flour or other provision rooms should be opened until all such foods have been cleared, nor should such provisions be embarked or transported with paraffin or other similar liquids.

Potatoes, fresh vegetables, fresh fruit and other fresh foods should normally be stowed in the cool rooms, in the stowages designed for them. If they have to be stored outside, care must be taken that they are not stowed between decks or in unventilated rooms. Potatoes develop poisonous gases, and fresh fruit and vegetables rapidly go bad unless they are continuously and freely ventilated. Fresh eggs are liable to be contaminated by smells and should therefore be stowed away from smelly articles and in a well-ventilated place.

It is essential to put refrigerated provisions into the cold or cool rooms as quickly as possible. The slightest delay, particularly in warm weather, not only results in the outside starting to thaw—which, for example, results in black mould on beef—but seriously affects the refrigeration of the provisions already in the cold or cool rooms.

Casks should be stowed in the racks provided, with their longitudinal axes fore-and-aft, bungs uppermost, and their bilges free (i.e. clear of the deck). If no racks are provided they should be bedded securely on dunnage (pieces of wood or other packing material) so that their bilges are free and their quarters supported. Each cask of a riding tier should rest with its bilges supported by the quarters of four casks of the tier below; spirit rooms are normally fitted with suitable racks.

It is essential that the transport of provisions to the provision rooms be properly supervised to ensure careful handling, and to this end speed should be sacrificed if necessary. This is especially important with provisions in sacks or packages, and if a container is holed or split it should either be repaired or the contents be transferred to a new one before stowing.

Preparing for provisioning

Arrangements should be made with the victualling yard for provisions which will be stowed in the same or adjacent store-rooms to be sent in the same lighter. Boatropes and fenders should be got ready for the lighters coming alongside, derricks should be rigged and power be supplied to the motor hoists, and mats should be placed at each dump. Three provision nets should be provided at each hoist. Hatchways leading down to the store-rooms should be cleared away and davits rigged if necessary; any hatchway from which the ladder has been removed must be roped off. Chutes, slides, roller conveyors and other storing aids should be prepared; shot-mats should always be placed at the bottom of each chute to prevent damage to the cases. Where it is necessary to transport casks from one compartment to another, ramps should be fitted and placed over the door sills.

All provision rooms, empty or otherwise, should be cleaned and swept, and any provisions remaining in them should be restowed in such a way that they will be readily accessible for issuing before the new stock. Clean tarpaulins

should be provided at each dump for protecting the provisions from contamination with the deck and keeping the deck clean, and for protecting any provisions stacked there from rain or a hot sun; it is particularly important to keep flour and other bagged provisions from getting wet and to prevent frozen meat from thawing. Adequate arrangements should be made for identifying and mustering the provisions as they are embarked and for supervising their transit from truck or lighter to the provision room in order to guard against pilfering, especially when any shore labour is employed; all provisions and naval stores are on charge to the Supply Officer, and he and his staff are answerable for any losses by pilfering.

Aircraft carriers—rapid loading and discharging

Experience has shown that, when embarking large quantities of stores in Aircraft Carriers, time and manpower may be saved by delivering the stores in lorries or trailers which may be hoisted inboard for unloading.

Using heavy wire vehicle slings, the lorries or trailers may be landed on the flight deck or struck down into the hangar, a single hoist doing the work of several separate slingings from the jetty. For discharging stores the procedure is reversed. The slings can be made in H.M. Dockyards.

Replenishment at sea

Replenishment of provisions, naval stores, oil fuel and ammunition is frequently carried out at sea from stores support ships, tankers and ammunition ships. These operations—which are carried out as evolutions, often involving all departments—are not only the most efficient ways of embarking supplies but are also less vulnerable to enemy interference in wartime. They are described in Chapter 11.

CHAPTER 13

Ship Husbandry

It does not matter how efficient the valuable machinery, weapons and equipment of a ship may be or how well they are maintained if the hull is rotten and the ship founders because her compartments are not watertight, her hatches will not shut and her bulkhead doors leak. Hull maintenance is therefore just as important as the maintenance of technical equipments. Ship husbandry defines that part of ship and hull maintenance that is not specifically within the province of the specialist technical departments; and although the greater part of the work is the responsibility of the Seaman Branch, all departments must contribute directly or indirectly.

A ship must be kept clean and tidy because, quite apart from the health and comfort of her company, cleanliness plays a direct part in hull maintenance, since dirt harbours moisture which leads to deterioration of every kind: and if gear, whether ship's or personal, is not stowed correctly and tidily there comes a time in emergency when it cannot be found or it has been scattered and may block the suction of a salvage pump at a critical time.

The ship's company must work as a team to maintain the ship in an efficient condition. If in the course of his work one man damages a piece of equipment or leaves a pile of dirt in the belief that someone else will clear it up, he is jeopardizing the safety of the ship and all those in it.

B.R. 2203, *Ship Husbandry Manual*, covers the whole subject of ship husbandry and must be read by all who serve in ships. This chapter is an extract from it.

HULL MAINTENANCE

Planning

Information on the condition of a ship's hull and fittings can be found in records compiled by ship's and dockyard officers and listed in B.R. 2203. To keep these records up to date a thorough examination of the hull structure and fittings must be carried out at regular intervals by a Shipwright officer or artificer and all defects listed. From this examination and the defect list, the plan of hull maintenance work can be made, giving priority to structure and fittings which affect watertight integrity and strength. Those defects beyond the capabilities of ship's staff are recorded for inclusion in the work undertaken by a dockyard during periods of refit. More information will be found in Vol. III.

Examination

Visual examination of the whole hull structure is a formidable task and best achieved as a continuous process, taking a section at a time whenever operational conditions permit. Regular inspection ensures that major material defects, such as cracks, loose rivets or excessive corrosion which will jeopardize the strength,

watertightness and safety of the ship, are recorded; it also ensures that measures taken to prevent deterioration and corrosion have been correctly applied and are still effective. Rounds by Commanding Officers and Heads of Departments provide opportunities for focusing attention on this important problem. Details of examination, what to look for, and places requiring special attention are given in B.R. 2203.

Testing compartments

If a ship is damaged below the waterline, flooding of compartments can be confined only if adjacent compartments are watertight. Regular visual inspection may discover some leaks, but to make quite sure that none has been missed in the vital watertight compartments, these must be regularly air-tested, either by raising the air pressure within the compartment and testing for leaks in all the adjacent compartments; or, more simply, by using negative pressure in the compartment and searching for leaks inside it. Both methods are described in B.R. 2203. Similar tests are carried out to prove the integrity of the gastight citadel.

CORROSION

Since the hulls of most ships of the fleet are of metal construction, by far the largest task of hull maintenance is prevention of corrosion, which occurs either by oxidation in the presence of oxygen and water (rusting) or by electrolytic action.

Rusting

In its natural state iron does not exist as a pure metal, it is obtained from ores, which are mostly oxides of iron, by processes which remove the oxygen and other impurities. It is then made into steel by the addition of other elements, principally carbon.

Unfortunately, iron and steel always try to combine with oxygen to revert to something like their natural state. Moisture is also needed for this process, and since air always contains some water vapour, and all water contains dissolved oxygen, the two harmful agents are always present. Salt in the water or air greatly increases the rate of reversion, so it can easily be understood why a steel ship rapidly rusts if no measures are taken to protect it.

Corrosion usually appears as a red rust; but sometimes, where there is much water but little oxygen, black scale is formed, which eventually becomes red rust as oxygen is absorbed.

The most practical way to prevent rusting is to coat the metal surface with a durable, non-porous film of paint so that neither air nor water can come into contact with it. But once this film is broken, however slightly, rusting will start; the rust then absorbs more moisture, particularly if the atmosphere is salt, and more paint film is forced away from the surface by the expanding rust to expose more bare metal to the air. The preparation of surfaces for painting and the application of paint will be described later.

Electrolytic action

When two different metals are in contact and placed in water containing dissolved impurities such as salt, they form a simple electric cell, a current flows between them and one of the metals is gradually dissolved. In a ship, where contact of dissimilar metals often occurs and salt water surrounds the hull and lies in the bilges, electrolytic corrosion takes place very rapidly, causing penetration over small areas (pitting) and finally holes in the plates.

One method of reducing the corrosion of steel in contact with brass or bronze is to put zinc corrosion pieces near the junction. The zinc corrodes by electrolytic action with the brass and the steel corrosion is almost completely halted. The corrosion pieces have to be replaced regularly. Other methods are described in B.R. 2203.

Aluminium alloys

The aluminium alloys used for ships' structures form a thin skin of oxide immediately they are exposed to air. It is tough and resistant to corrosion even in wet, salt-laden atmospheres. But serious electrolytic corrosion can be started immediately tiny particles of other metals become embedded in the surface of the plates, and pitting begins as soon as the plates are wet. Special instructions for the care of these alloys are given in B.R. 2203.

GENERAL MAINTENANCE AND CLEANING

CARE OF WATERTIGHT CLOSURES

The term 'watertight closures' is here taken to include all doors, hatches, manholes and scuttles in watertight decks and bulkheads, also external covers for ventilation inlets and discharges. Their efficient maintenance and working is as important to the safety of a ship as the structure itself—chiefly to restrict the spread of flooding and to restore services by isolating sections of the ship in the event of damage.

Operation

Never drop or slam watertight closures, nor close them on any obstruction; such action causes distortion of the metal and damages the jointing material. Take care, when handling heavy articles, not to damage a sill or coaming. When closing, apply clips lightly and evenly all round the door or hatch, then tighten the diagonally opposed pairs of clips until the hatch or door is pressed firmly on to its seating. For properly maintained hatches and scuttles hand pressure is always sufficient—*never use mechanical aids*. Door clips may be finally levered into position, using the lever provided for this purpose.

Maintenance

This should normally entail no more than regular inspection, operation and lubrication of hinges and clips, and the cleaning of rubber joints and the faces on which they bear. Hard paint can be removed from rubbers by rubbing with

a stick of tapered hard wood; never use solvents such as white spirit. Grease and oil can be removed with a detergent solution.

For those ships not adopted by Class Authorities (see Vol. III), the recommended frequency of maintenance routines and a list of likely defects, their causes and remedies, are given in B.R. 2203.

Defects

It is the duty of all those who use a watertight closure to notice defects in their operation and to report them at once.

Other closures

Bulkhead valves in pipe systems and ventilation trunking, storm valves on soil pipes and scuppers, electric cable glands, rod gearing, telegraph shafting, etc. are the responsibility of the specialist departments. Their work is made easier if the following simple rules are obeyed:

Do not paint the operating spindles, threads or moving parts of any valve.

Do not paint over lubricating points or grease nipples of valves or over bearings and bevel wheels of rod gearing and telegraph shafting.

Do not paint the neck bushes, studs or nuts of bulkhead and deck glands.

Do not hang anything on any part of any valve or rod gearing.

CARE OF BATHROOM FITTINGS

The misuse of bathroom fittings causes much unnecessary maintenance effort.

Do not remove washbasin plugs.

Do not force swivel-type shower heads if they become stiff or seized.

Do not use taps, mixing-valves or pipes as strong-points for wringing out washed clothes.

Do not bend shower pipes to alter the direction of the stream.

CARE OF SOIL PIPES, SCUPPERS AND DRAINS

Blockages in these systems usually involve stripping and dismantling pipes and releasing filthy water and obnoxious smells into living spaces. All this can be avoided if the systems are used properly.

Never remove scupper gratings except to clean them.

Never pour grease or fatty waste down galley drains.

Keep the decks free from dirt which, when washed down scuppers, would block them.

Use only the proper toilet paper in the heads.

Never throw matches or cigarette ends into urinals, nor pour dirty water down the lavatory pans—it is the soap, scrubbers and cloths that cause the blockages.

Flush the soil and urinal pipes regularly through the connections provided;

this reduces the fouling and therefore the frequency of dismantling and cleaning.

VENTILATION SYSTEMS

Maintenance

This requires good organisation and co-operation so that the work of several departments may be undertaken at the same time. It involves either the simple cleaning, lubricating and operating routines carried out at regular intervals by non-skilled ratings; or the more complicated stripping, examination and testing of components by skilled ratings.

The greatest hindrances to efficient ventilation are dirt and seizure of moving parts by paint or lack of lubrication. Dirt on the inner surfaces of trunking, on heating and cooling elements and on fan blades and casings, slows down the flow of air and can reduce the volume delivered by as much as a half. Seizure of moving parts makes it difficult to close down ventilation rapidly for NBCD purposes.

Cleaning

Dirt and fluff loosely adhering to the internal surfaces of trunking can be removed by vacuum cleaner or by blowing it out with low-pressure air. The more firmly adhering dirt can only be removed by brushing with a stiff bristle brush. Before undertaking extensive painting of compartments, it is recommended that the ventilation trunking associated with them should be cleaned as thoroughly as possible.

All men employed blowing through *must* wear face-masks (as for spray-painting).

DECKS AND DECK COVERINGS

Wooden decks

Sweep up all dirt before scrubbing so that it will not be scrubbed into the wood; then use water sparingly. If salt water is used keep a bucket of fresh water handy so that salt-water splashes can be wiped off paintwork and fittings. Allow the deck to dry thoroughly before permitting traffic on it.

If a wooden deck is very dirty, a little sand scattered on the deck when scrubbing helps to remove ingrained dirt, or the deck may be holystoned, but this should be done infrequently because it wears down the deck—especially if it is made of soft wood.

An alternative to holystoning, but not so effective, is to scrub the deck with a solution of washing soda or a solution of soft soap and cleaning powder. A solution of caustic soda (1 part in 300) may also be used, but it can ruin paintwork and damage aluminium alloys if allowed to splash on them.

Oil and grease stains should be coated with a mixture of lime and fresh water, which must dry thoroughly before it is scrubbed off. The lime absorbs the oil or grease, but a second treatment may be needed. If it is known that greasy or

oily gear, such as cable and wire hawsers, are to be ranged on deck, cover the deck with a protective coating of lime.

Steel and aluminium decks

External and internal decks protected by paint are prepared for painting and then maintained in the same way as any other painted metal surface.

Unpainted internal decks must be kept dry, clean and free from rust. Abrasive tread strips, which are laid ¼ in. apart in areas of heavy traffic and 6 in. apart elsewhere, are replaced by ship's staff when worn, unless the deck is heavily pitted, when dockyard assistance is required. Instructions for laying these strips are given in B.R. 2203.

Cork linoleum

Deck covering of cork linoleum (in rolls or tiles) is supplied in several colours and is laid over decks of accommodation spaces. It is cleaned by sweeping up loose dust and grit with a soft brush and washing with a cloth damped in a warm detergent solution. Water should never be swilled over the surface of linoleum, nor should cleaning powders, caustic soaps or coarse abrasives be used.

It can be polished with plastic polish, wax or wax emulsion.

Carpets

New carpets tend to 'fluff', the fluff being the short wool fibres which do not reach the base of the pile. To increase the life of a carpet the fluff should be allowed to remain in the carpet for a few months and heavy brushing and vacuum cleaning must be restricted.

After a few months carpets should be swept daily and cleaned with a vacuum cleaner once a week.

Hard shaking or beating of small rugs loosens the hem and damages the fabric.

To reduce the wear at doorways and between furniture, carpets should be turned from time to time.

Bathroom deck covering

White, unglazed, vitreous tiles or neoprene terrazzo are used. Both types are best cleaned with warm water and a mild soap. Heavy scrubbing, abrasives or strong detergents should never be used on latex, because they destroy the coats of sealing lacquer.

WOODWORK

Salt water is best for scrubbing bare woodwork; sand may be used to remove ingrained dirt, and shark-skin gives the best finish. Soap should never be used, because it leaves the wood greasy and tends to stain it yellow.

Polished wood should be wiped with a cloth damped in fresh water; then it should be dried and polished with furniture polish.

FURNITURE AND FITTINGS

Washbasins of stainless steel or enamel are best cleaned with a soft cloth and the standard detergent solution; never use wire wool or abrasives.

Lavatory pans and urinals should be cleaned with soda ash. Neither commercial acid sodium sulphate, as used in Shore Establishments, nor proprietory brands of cleansers should be used in ships, because they corrode the metal parts of W.C.s and soil pipes. Dilute hydrochloric acid may be used to remove stubborn stains or to burn out blocked soil pipes, provided that the systems are very thoroughly flushed afterwards.

Curtains and overcases are normally sent ashore for dry-cleaning, either through the S.N.S.O. when in or near a dockyard, or by arrangement between the Supply Officer and a local firm of dry-cleaners when away from a dockyard. Abroad, if no proper facilities are available, they can be washed with soap and warm water, rinsed, dried and ironed, taking great care to avoid shrinkage. It is inadvisable to use the ship's laundry, because the detergent powders and heat will probably shrink the material and the colours will fade.

Glass should be washed with soap and warm fresh water and then polished with soft paper—newspaper will do. Paint marks can be removed without scratching the surface by wetting and rubbing with a copper coin laid flat.

Leather, hide and PVC leathercloth should be washed with soap and warm water; for daily cleaning a wipe with a cloth dipped in soapy water and wrung out almost dry is sufficient. Ingrained dirt can be removed by scrubbing lightly with a small brush. Excessive use of water on upholstered furniture rots the stuffing and stitching.

Dubbin or neats foot oil should be rubbed into leather that is exposed to the weather.

Plastic-topped tables (e.g. Formica and Warerite) are much more hard-wearing, hygienic, easy to clean and colourful than plain wood, but they are not completely resistant to heat, sharp implements and coarse abrasion, and they are very expensive.

Clean with a damp cloth or with hot, soapy water. Stubborn stains can be removed with detergent powders or domestic bleaches, but abrasive powders or scourers must not be used.

Use mats under hot plates and dishes; do not iron on the table tops, and be careful not to leave cigarettes burning on them.

BOATS, WEATHERDECK GEAR, ANCHORS AND CABLES

The ship husbandry for these subjects will be found in the relevant chapters of this book.

PAINT AND PAINTING

The primary object of paint is to provide an airtight and watertight protective coating for metal or wood surfaces in order to prevent them from rusting, corroding or rotting. It is coloured for the sake of appearance. Since the Royal Navy is one of the largest consumers of paint in the country, it is only right that ships should know how to prepare surfaces for painting, the correct paints to use and how to apply them, otherwise there will be considerable waste of money and time.

Paint

Paint is a mixture of ingredients called pigments, binders, solvents and driers. The *pigment* is the basic ingredient which gives the paint its colour and protective quality. It is in the form of a fine powder or a paste and consists of such substances as white lead (the basis of most oil paints), red lead, zinc oxide, zinc chromate and aluminium. The *binder* holds the pigment particles together and gives the paint its adhesive quality. It usually consists of linseed oil, tung oil or synthetic resins. The *solvent* is added to the pigment/binder mixture so that the paint can be spread evenly. It consists of white spirits, turpentine, naphtha or other special chemical products, all of which evaporate after the paint has been applied. The *drier* assists the paint film to dry reasonably quickly.

Most of the paints supplied to H.M. ships are ready-mixed in drums and need no preparation other than a thorough stirring before use. Thinning with a little white spirit is only necessary for spray-painting.

Types of paint

Synthetic-resin paints are composed of a special pigment with a synthetic resin binder and solvent. They provide a good, durable finishing coat with a mat or semi-glossy surface, and though inflammable in liquid form they are fire-resisting when applied as a coating. They are generally used in the Royal Navy for weather and interior work.

Oil paints are those with a binder and solvent of oil. Since they are inflammable they are no longer used in H.M. ships.

Lead paints are those whose pigments contain lead. Their use in confined spaces such as double bottoms is prohibited, because they may cause lead poisoning.

Water-paints or distempers are those with a binder and solvent of water or oil emulsion. They provide a mat surface, and though not so durable as other paints they are less likely to crack and peel off a surface which expands or contracts or alters its shape. They are therefore used for painting the lagging of steam pipes and the insulating surfaces of Paxtiles and Paxmarine.

Varnishes consist mainly of resin dissolved in some form of spirit. They are quick-drying, expensive and highly inflammable and are used in the Royal Navy only to provide a very hard, glossy surface to the woodwork of 14-ft sailing dinghies.

Enamels provide a very hard and durable glossy surface impervious to water, but liable to crack from maltreatment or exposure to intense heat or cold. Being expensive and very inflammable before and after application, they are not used in the Royal Navy.

Plastic emulsion paints, used extensively now for internal decoration of houses, give no protection to steel surfaces and are therefore unsuitable for use in ships. But they are sometimes used for internal painting of submarines, where the slow evaporation of other solvents is unacceptable.

Cellulose paints, sometimes called 'dope', are very quick-drying and are used chiefly on aircraft. Naphtha, which gives off noxious fumes, is used in the binder and solvent, so the paint may only be applied in specially ventilated compartments and the painter must wear a suitable respirator.

Outer-bottom compositions are special paints designed to give a protective coating to the underwater surfaces of the hull. They are of two quite different types, known respectively as 'anti-corrosive' and 'anti-fouling' compositions.

The anti-corrosive composition is applied first, in two or more coats, and protects the steel against the corrosive action of salt and other impurities in the water. The composition is supplied in two colours (red and chocolate), so as to enable one coat to be distinguished from another as it is applied. Ships built before 1958 are painted with 'Admar' which is supplied in three colours, red, black and chocolate.

One coat of an anti-fouling composition is applied over the anti-corrosive composition; it contains chemicals which slowly dissolve or 'leech out' during the life of the paint and are poisonous to marine growths such as weed, and to marine parasites such as barnacles. The anti-fouling paint is supplied in two colours (red and black). The outer bottoms of submarines are painted with a black anti-fouling paint.

The bottoms of wooden ships are usually sheathed with copper or Nylon duck; although copper sheathing needs no protective coating, the Nylon sheathing is preferred as offering better protection.

Paint coats

The *primary coat*, which may consist of one or two applications, is the first coat of paint. The paint is called a *primer* and it has special properties of adhering to a new surface and of checking corrosion; it also provides a mat (i.e. non-glossy) surface to which the next coat will easily adhere; but because it is porous it does not provide a weatherproof covering. Examples of primers are red lead for steel, zinc chromate for aluminium and aluminium paint for wood.

Since a primer provides the basic protection of the surface it is the most important coat. It must be applied by brush and be well worked in so that it completely covers the surface, particularly the awkward corners and the roughened areas.

The *undercoat* must completely cover the primer, leaving a mat surface to improve the adhesion of the top coat. It may be applied by brush, roller or spray.

The *top coat* is designed to give a good, durable finish that will look well. It may be applied by brush, roller or spray.

Paint schemes

Different materials may require different types of coats and different methods of application; for example, steel and wood require different primers; the coating for one part of a ship may not be the same as that for the same material in another part. The required types of paint, the number of coats and the method of application are together known as a 'paint scheme'; in this the undercoat and the top coat are specified under the heading 'finishing coats'.

The paint schemes for ships adopted by Class Authorities are given in Hull Maintenance Schedules. Those for ships not adopted are given in B.R. 2203.

CLEANING AND RENOVATING PAINTWORK

Washing

When paint is in good condition but dirty—i.e. when it still retains its gloss and good adhesion over all its area, is not excessively thick and shows no sign of corrosion—washing is sufficient to restore its appearance. The whole surface is first washed with warm soapy water or a warm solution of detergent fluid. When all dirt has been removed the surface is rinsed with clean, fresh water and then dried with a clean sponge or cloth.

Because they ruin the gloss, soda or other alkaline cleansing agents should not be used on paint, and must never be used on aluminium.

Refurbishing old, but generally sound, paintwork

When paintwork is in moderate condition—i.e. when it has lost its gloss, shows a few patches of rust, but still has good adhesion generally and is not too thick—there is no need to scrape the surface to the bare metal and repaint: scraping and re-priming the rusty patches and renewing the finishing coats are sufficient to restore its protective qualities and appearance.

First remove areas of rust and defective paint, cleaning down to the bare metal (see following paragraphs for various materials); then touch up the bare areas. If interior quality paint is to be used, apply one priming coat and one finishing coat. If exterior quality paint is to be used, apply priming coat(s) only.

When necessary, wash with a 50/50 mixture of naphtha and white spirit to remove all grease and oil, wash the whole surface with soapy water or detergent, then rinse with fresh water and dry the surface.

Rub the whole surface with sandpaper or wet pumice-stone, carefully smoothing the edges of the patches that have been touched up.

Remove all dust with a dry cloth or by washing with fresh water and thoroughly drying afterwards.

Paint the whole surface. If interior quality paint is to be used, apply one coat of finishing coat only. If exterior quality paint is to be used, apply one undercoat and one finishing coat.

Renewal of complete paint scheme

When the paint is in bad condition—i.e. when it is crazed, cracked, blistered, flaking, very thick or shows considerable corrosion—the whole area must be

cleaned down to the bare metal and painted again. All rust, scale, loose paint, dirt, grease, oil, salt deposit and moisture must be removed, because dirt and loose particles under new paint prevent proper adhesion and give a rough surface with thin—and therefore porous—spots; grease and oil prevent proper adhesion, as well as retarding drying and spoiling the gloss of the final coat; and moisture causes blistering and encourages rusting below the paint.

PREPARATION OF SURFACES FOR PAINTING

Ungalvanised steel

Remove all the old paint with pneumatic or electric scaling machines, resorting to hand scraping and scaling for inaccessible corners and areas of rust or extra-hard paint spots. Take care not to score the steel surface deeply.

Wire brush the whole surface with power-driven brushes.

Precautions. Inhalation of lead paint dust can cause lead poisoning, therefore men employed scaling and wire-brushing lead-painted surfaces must wear overalls and respirators; they must wash their faces and hands thoroughly with soap and hot water after work; and they must rinse their mouths before eating, drinking or smoking. Goggles must be worn by all men chipping, scraping or scaling. Respirators must be worn by men scaling or wire-brushing with power tools in confined spaces.

Removal of rust. Rust in places inaccessible to scaling, scraping and wire-brushing—e.g. in certain corners, in the rough surfaces of welds and in deep pitting—can be removed with derusting fluid. The method of using, and precautions to be taken when using, derusting fluid are given in B.R. 2203.

Galvanised steel, zinc-sprayed steel or aluminium

These metals have a protective film on their surfaces which would be damaged by chipping, scaling or wire-brushing. Paint-remover is applied with an old brush and allowed to remain for 20 to 30 minutes. Then the softened paint can be scraped off with wooden scrapers, great care being taken not to scratch or cut the surface of the metal. A second application of paint-remover may be necessary. When all paint has been removed, the wax deposit is removed with a 50/50 mixture of naphtha and white spirit.

Precaution. Paint-remover and naphtha give off toxic fumes. Adequate ventilation must therefore be provided and NO SMOKING boards placed when it is used inboard (see B.R. 2203).

Removal of corrosion products and roughening surfaces. See B.R. 2203.

Wood

Old paint can be removed by 'burning off' with blow-lamps or gas torches (only by men trained to use them) and scrapers; or by using paint-remover as above. The surface should then be smoothed with sandpaper.

Precautions. Paint must not be burnt off when paint-remover is being used in the vicinity. Adequate ventilation must be provided. Proper fire precautions must be taken, especially on the reverse side of bulkheads.

Knotting and stopping. After rubbing down, bare knots are coated with knotting; holes, cracks and uneven surfaces are filled with hard stopping (see B.R. 2203).

Copper and brass

Fine emery cloth should be used to roughen copper and brass, and the surface should be degreased both before and after roughening.

STORAGE AND PREPARATION OF PAINT

Every drum of paint should be inspected when first received on board. The contents of any rusty, badly dented or split drums must be examined and, if fit for use, placed on one side for immediate use. If the contents are unfit for use, or reduced by leakage, the drum must be returned to Naval Stores for survey.

Storage

Sound drums are stored in racks in the Paint Store, grouped according to type, maker, batch number and date of manufacture (all stencilled on the drum); the oldest paint being stowed at the front for earlier use. The stock should be kept as small as possible; the oldest paint should be used first and, wherever possible, the drums should be up-ended from time to time to prevent the heavy pigments from settling on the bottom.

Mixing

When preparing to paint large weatherwork areas the contents of many drums must be mixed to give uniform colour and consistency. Ideally all drums should be of the same batch number and date of manufacture.

First estimate the amount of paint required, allowing roughly one gallon for every 400 sq. ft for brush painting and rather less for roller and spray painting. Mixing is usually done in a large tub (or drum) on the upper deck or the jetty. It is essential that drums be thoroughly stirred until all the more solid pigments which have settled on the bottom are broken down and completely mixed into the paint to form a smooth homogeneous mixture before it is poured into the tub; the tub should be topped up whenever it is half-emptied, thereby helping to maintain a uniform colour and consistency. It is better to mix more, rather than less, paint than is required, because paint of the same colour will be required for touching up.

When paint is exposed to air it forms a skin, which has to be removed from pots and opened drums. The skin can be removed in one piece if it is thick enough, otherwise the paint must be stirred and strained. Paint should not, therefore, be left in pots but poured into a ready-use tank in the short intervals of a painting task; when the task is finished, spare paint should be sealed in full drums.

Empty pots should always be brushed out and cleaned before storing. Accumulations of old, dried paint should be scraped or burnt out. Permission must be obtained before burning out pots ashore in H.M. dockyards.

PAINTING

Anyone can slap on a coat of paint, but it takes much practice and skill to apply paint so that it gives full protection to the surface and has a pleasing finish. Training courses and films are listed in B.R. 2203.

Brush painting

Always use clean pots and brushes; good painting is impossible with brushes that are dirty or have distorted and splayed bristles.

Before use make sure that loose hairs are removed from new brushes by stroking the bristles to and fro briskly with the hand so that they are pressed at right-angles to the handle and flip back quickly.

Keep one side of the pot free from paint so that the handle of the brush can be laid on the clean side when the brush is laid across the pot.

Hold the brush perpendicular to the surface being painted.

Work priming coats—such as red lead, yellow zinc chromate and aluminium paint—well into the surface.

Remember that frequent use of white spirit or similar solvents for cleaning the hands may cause dermatitis.

Use worn brushes for red lead, weatherwork finishing coats and varnishes.

Never use a flat brush edgewise except for cutting-in.

Never use the same brush for different types or colours of paint unless it has been thoroughly cleaned.

Application. The paint pot should never be more than two-thirds full. The paint should be stirred frequently with a stick to keep it consistently smooth.

The brush should be held between the thumb and first three fingers.

Dip only a third of the length of the bristles into the paint; otherwise paint will collect and harden in the heel of the brush so that the bristles will become distorted and very difficult to clean.

A brush that is too heavily loaded drops paint and produces an untidy and uneven surface. Tap the brush against the side of the pot to remove surplus paint.

The initial brushing is called 'laying on' and, for a 3-in. brush, should cover 2 to 4 sq. ft. The paint should then be brushed over horizontally and then vertically a couple of times to make sure that it is spread evenly and smoothly. The final brushing, which is called 'laying off', should be vertical to reduce the tendency for certain types of paint, such as red lead and weatherwork finishing coats, to sag and wrinkle when applied to large, plain surfaces.

Care of brushes

New brushes should be stored flat in paper in a cool, dry cupboard with some camphor or insecticide to protect the bristles. When drawn from store the brush handles should be drilled so that they can be hung up when not in use or attached to a lanyard when working aloft or over the side. A day or two before they are first used the bristles should be wrapped in thick paper and hung in raw linseed oil, which can be pressed and rinsed out with white spirit immediately before use.

Brushes in use must be cleaned when painting has finished for the day. Work the paint out of the bristles against the edge of the pot; squeeze out loose paint with the blade of a putty knife; clean the handle with white spirit, then hang the brush in a mixture of white spirit and boiled linseed oil so that the bristles are immersed to ½ in. above the ferrule.

If brushes are kept in water the paint hardens in the roots of the bristles and reduces their flexibility. When the brushes are used again, the paint comes away in hard particles as it is loosened by the paint solvent and spoils the surface being painted. If brushes are hung in white spirit, the bristles harden and split.

When work is completed used brushes should be thoroughly cleaned with white spirit until all the paint has been worked out of the heels. Each brush should then be rinsed in clean white spirit, dried by spinning the handle between the palms of the hands, washed in soapy water, rinsed, dried and laid flat.

Brushes used for distemper must be cleaned daily after use. Scrape off thick deposits with a knife, then wash in warm soapy water until all the distemper has been worked out of the heels. Rinse in clean water, dry with a rag and store away by hanging or laying flat.

Brushes used for varnish may be left suspended in varnish, with the bristles completely covered and the container closed to keep out dust; or they may be cleaned with white spirit (or other solvent), dried and laid flat.

Brushes that have been used and stored in oil varnish must be cleaned with white spirit before being used with spirit varnish; those that have been used with spirit varnish must be cleaned with methylated spirits before being used with oil varnish.

Roller painting

It is more economical to paint large, flat surfaces by roller rather than by brush painting. The paint is held in a special container which has a ribbed, sloping tray on which the roller is charged by immersing a narrow strip of its covering in the paint and rolling it up and down the tray until the paint is evenly distributed over the whole surface of the roller.

It is recommended that the rollers, when drawn from store, should have their handles drilled, and that both rollers and trays should be secured by lanyards when used aloft or over the side; also, when making up stages for painting over the side, a hook should be spliced into one of the lashings so that the trays and rollers may be secured while the stages are being adjusted.

Application. The roller should be undercharged rather than overcharged with paint; it may then be worked over the surface in any direction with short strokes and no sliding. The best finish is obtained if the surface is crossed at least twice horizontally and vertically, laying off vertically upwards.

Inaccessible corners and lap joints must be brush-painted just before rolling, so that the paint is still wet and an even junction is achieved.

Cleaning equipment. Rollers and trays must be thoroughly cleaned after each day's work. Paint that hardens in the roller fabric cannot be effectively removed.

First pour back as much paint as possible from the tray into the drum, then wipe the tray with an old rag and fill with white spirit. Remove as much paint

as possible from the roller by working it over sheets of newspaper, then work it in the tray and dry out. Then wash the roller in soap and warm water, rinse, remove surplus water with a clean rag, and hang up to dry.

If the white spirit (or other solvent) used for cleaning the roller is kept in a closed container, the paint pigments will settle and the clear spirit can be decanted for further use.

Spray painting

Spray painting is a quick and very efficient method of painting large surfaces and areas covered with electric cables, pipes, fittings, etc., where rollers cannot be used and brush-painting is wasteful of labour. On the other hand, the preparation—i.e. covering areas not to be painted, rigging and cleaning the equipment and final clearing up—take very much longer than for brush and roller painting.

Spray painting is ideal for large enclosed spaces, such as messdecks, but it must never be used in compartments containing electronic, radio or weapon control equipment.

The cleaning, maintenance and precautions to be carried out when using spray painting equipment, and also the spraying technique, are all described in B.R. 2203.

Painting the ship's bottom

Preparation. The underwater surface of the hull is prepared for painting by projecting a blast of wet grit (grit-blasting) all over it, or by scaling, scraping and wire-brushing it, by either hand or power.

When the ship is docked for repainting her bottom all marine growths are scraped off as the water recedes by gangs of men standing on catamarans and equipped with long-handled scrapers. Lines should be rigged on each side from bow to stern just above the waterline to enable the catamarans to be hauled and secured in position. After all mud and marine growths have been removed the scaling, scraping and brushing is done from stages rigged from the bottom of the dock, and the whole surface is then washed or hosed down with fresh water.

All scuppers and other discharge openings in the hull are plugged or fitted with pipes to carry water clear of the side, so that those painting will not be drenched and the side and bottom will remain dry.

Application. Bottom compositions may be applied by brush or spray and each coat must be dry before the next is applied. The 'boot-topping', i.e. the strip between wind and water, consists of the same compositions as those used on the bottom; the top coat is usually black.

DEFECTS IN PAINTWORK

Blistering

If paint is applied over moisture the moisture evaporates and expands when heated and a blister forms. The better the paint the more impervious it is, and the more effectively is the damp trapped beneath it.

Make sure that the surface is thoroughly dry and free from corrosion products before painting, and avoid painting in damp or humid conditions.

Blistering on galvanised steel is sometimes caused by saline matter from the galvanising process remaining in small fissures and absorbing moisture. The cure is to remove all paint, degrease and recoat.

Peeling

The top coat of a paint will peel if it is applied over moisture, salt deposit, wax, polish, oil or grease; or if the top coat of a hard-gloss paint is applied over a smooth, glossy surface. Therefore paint must be applied to clean, dry, mat surfaces, free from grease and oil, and in good weather conditions.

Sagging

When the gloss paints and varnishes are spread unevenly or too thickly they tend to sag. They should be applied with well-worn brushes and, when possible, finally laid off lightly and vertically.

Bittiness

Any extraneous matter, such as dirt in brushes or on the surface being painted and paint skins, causes 'bittiness'. It can be avoided by straining the paint or varnish and applying it with a clean brush on a clean surface.

Cracking

When a quick-drying paint is applied over a more elastic coating, complete breaks in the paint film expose the underlying surface. It will not occur if the specified painting schemes are followed and the paints are in good condition.

Brush marks (ropiness)

Unsightly brush marks remain when the paint fails to 'flow out' after it is applied. They may occur when the paint is too thick or the brushes are of poor quality, or if too much pressure is applied in the final laying-off.

Discoloration

Paint may lose its colour through chemical reaction with the air, from dirt deposited on it, from the effect of heat and light, from contamination from fuel oil or bituminous material if the paint was applied over it, or from washing with strong alkaline solutions. Not all of these factors can be controlled, but some discoloration can be avoided by thorough preparation before painting and the avoidance of all strong alkalies when cleaning.

Non-drying

Service paints in good condition and thoroughly stirred should dry within a reasonable time. If they do not, then:

- the surface may have been dirty, oily, greasy or polished,
- the paint may have been applied too thickly,
- driers may have been added and have unbalanced the composition of the paint,
- paraffin or similar oils may have been used as thinners,
- there may be insufficient ventilation,
- the weather may be unfavourable.

CHAPTER 14

Ceremonial

Most ceremonies are an expression of respect, courtesy, rejoicing or sorrow, and so their form varies and must also be adapted to suit local circumstances. Ceremonial plays an important part in the life of a sailor of the Royal Navy, and he must therefore have a good knowledge of its naval forms and of the customs and traditions upon which these are founded.

Nothing in this chapter should be read as specifically authorising any particular procedure or conduct, and where any doubt as to the correct procedure may arise *The Queen's Regulations for the Royal Navy* should always be consulted and obeyed. When interpreting the regulations it should be borne in mind that offence may be given by not according some recognised mark of respect, and on the other hand marks of respect will be depreciated if they are used indiscriminately in the interest of flattery or ingratiation; the only way to avoid both is strictly to observe the regulations.

Wearing of colours

Strictly speaking, a suit of colours worn by any of H.M. ships in commission comprises the White Ensign, the Union Flag flown as a jack, and the masthead pendant, but if the ship is a flagship the distinguishing flag of her flag officer replaces this pendant. In general, however, the term 'colours' is understood to mean the ensign and jack only. Particular care must always be taken to ensure that these colours are hoisted close up and not foul of the mast, staff, or rigging; also that the halyards are taut and the lacing set up correctly. The manner in which a ship wears her colours is an indication of her smartness.

The ensign and jack are worn during the prescribed hours by H.M. ships at anchor, secured to a buoy or berthed alongside; but when the ship gets under way (i.e. when the last anchor is aweigh, the sliprope slipped from the buoy, or the last hawser let go) the jack is lowered and it is not rehoisted until the ship again anchors, secures to a buoy or berths alongside (i.e. until the first anchor is let go, the picking-up rope brought to the capstan or the first hawser secured).

There are, however, certain exceptions to these rules. A ship under way in harbour wears her ensign whenever there is sufficient light for it to be seen. A ship at anchor in harbour hoists her ensign at times other than during the prescribed hours to disclose her nationality or identity to a ship entering or leaving harbour, or to acknowledge the salute of a passing merchant ship. The only two occasions when a jack is worn by one of H.M. ships under way are: when she is under way in a harbour and ships not under way are dressed overall; and when she is wearing the Royal standard or escorting a ship in which the Sovereign is embarked. For reasons of economy the jack is not worn by ships in dock or by ships undergoing a dockyard refit.

Ensigns are half-masted to indicate a death. They are usually half-masted on the day of the funeral only, from the time the body leaves the ship or place

where it has been lying to the time when it is buried. When the ensign is ordered to be half-masted throughout the day it is first hoisted close up at 'Colours' and then lowered to half-mast, and at sunset it is first hoisted close up from half-mast and then lowered.

The following notes on the ceremony attending the hoisting of colours in harbour are given as a general guide:

(i) The Officer of the Watch should report personally to the Captain five minutes before the time of 'Colours'.

(ii) If foreign warships are in company the band plays the national anthems of their countries after ours, playing first the anthems of the countries represented by Flag Officers in the order of seniority of those officers, and the remainder in an order varied from day to day.

(iii) When in a foreign port the national anthem of the country of that port is played immediately after our national anthem.

(iv) The 'Carry on' is not sounded until the full ceremony is over, and all hands on deck (other than those on the quarterdeck) remain at the salute until the 'Carry on' is sounded. All hands on the quarterdeck come to the salute as the guard executes the last motion of the 'Present arms', and returns from the salute with the last motion of the 'Slope arms' or 'Shoulder arms'.

(v) If a band is not paraded the bugler sounds the 'General salute' in place of the national anthem.

(vi) If a bugler is not available the 'Still' is piped on the boatswain's call by the quartermaster of the watch at the appointed time; the colours are hoisted in silence, and the 'Carry on' is piped on completion. When in company the time of piping the 'Carry on' is taken from the Senior Officer present.

(vii) Guards and bands are not usually paraded for 'Colours' on Saturdays and general drill days.

Dressing ship

Ships are dressed overall in harbour at the same time as the colours are hoisted. If under way at the time of 'Colours' a ship is dressed as soon as she anchors or berths alongside. Before dressing ship the whips are manned and the down-hauls tended, the men are stationed aloft to guide the dressing lines and flags clear of any obstructions. When the 'Preparative' flag is hauled down the 'G' is sounded on the bugle, and at this signal the lines are triced into position simultaneously and then set up taut by tackles or slips on deck. The ceremony of 'Colours' is carried out immediately after the lines are triced up.

Ships in harbour dress overall with flags from 'Colours' to sunset on the following occasions:

anniversaries of the dates of the accession and coronation of the Sovereign;

H.M. the Queen's official birthday (as notified in the *London Gazette* and promulgated annually in *Defence Council Instructions*) and the birthdays of H.R.H. Prince Philip the Duke of Edinburgh and H.M. Queen Elizabeth the Queen Mother;

NOTE. If the actual date of the Sovereign's birthday is not the official date,

ships dress with masthead flags only during the firing of the gun salute on the actual birthday. If the actual date falls on a Sunday, ships will be dressed overall only in ports where official celebrations are being held ashore.

Commonwealth Day (24th May);

by order of the Senior Officer present on the occasions of visits of royal personages, or on certain foreign ceremonial occasions.

Ships under way in port, or ships not fitted for dressing overall, dress with ensigns at the mastheads, and at the same time hoist the Union Flag at the jackstaff.

Flying of distinguishing flags

When a Flag Officer or a Commodore hoists his flag or broad pendant in a ship, that ship is known as the flagship of his particular command. The distinguishing flag of a personage other than a Flag Officer or a Commodore may, with the approval of the Senior Naval Officer of the station, be flown by one of H.M. ships when the personage is embarked in her on the public service within the limits of the former's command or authority.

In home waters, on the day when a Flag Officer relinquishes his command, his flag and that of his successor are each hoisted in different ships or establishments and remain flying during the day of transfer of the command.

A Flag Officer's flag is only struck in the following circumstances:

when he relinquishes his command;

if he is absent through sickness or is in hospital;

if he is absent on leave for a period exceeding 48 hours (on home service only);

when he dies.

A Flag Officer's flag is hauled down when the Royal standard and the flag of the Lord High Admiral are hoisted; it is displaced when the Royal standard only is hoisted.

On the death of a Flag Officer his flag is half-masted from the time he dies until sunset on the day of his funeral, when his flag is first hoisted close-up and then finally struck.

Should a Flag Officer be killed in battle, his flag is not half-masted until the action is ended.

These remarks on the flying of Flag Officers' flags apply also to the flying of the broad pendants of Commodores.

In the days of three-masted ships an Admiral flew his flag at the main, a Vice-Admiral at the fore, and a Rear-Admiral at the mizzen. Nowadays, the flag of an Admiral of the Fleet, an Admiral, or a Commander-in-Chief is flown at the main and other Flag Officers fly their flags at the fore masthead if there are two masts.

An Admiral of the Fleet flies the Union Flag as his proper flag.

In destroyers and similar ships the principal mast is the foremast, the aftermast being known as the mizzenmast. In these ships flags of rank are hoisted at the foremast, the mizzenmast being reserved for the ensign when it is not worn at the ensign staff.

Flag and senior officers' distinguishing lights

In peace-time, both in harbour and at sea (except when steaming without lights), the flagship or the ship of the Senior Officer of a squadron or flotilla is distinguished by a white top-light, showing abaft the beam and usually displayed at the maintop. In harbour, in addition to the top-light, a flagship is distinguished by one, two or three all-round white lights denoting, respectively, a Commodore or Rear-Admiral, Vice-Admiral, and an Admiral or Admiral of the Fleet. These lights are usually displayed athwartships on the poop or after superstructure, below the top-light and clear of the normal stern light.

Other ships (i.e. 'private ships') may often be distinguished from each other at night by a cluster of lights representing their initial letters, displayed at the gangway.

Piping the side

Except for foreign naval officers, for whom the side is piped at all times, the side is only piped to the following persons, and only between the times of 'Colours' and sunset:

Her Majesty the Queen;

H.R.H. Prince Philip the Duke of Edinburgh when in naval uniform;

members of the Royal Family of the rank of Captain, R.N. or Reserve and above, when in naval uniform;

Commonwealth Naval Boards when acting as Boards;

officers of flag rank in uniform and Commodores in uniform;

an officer in uniform if holding an appointment in command of a sea-going ship or tender in commission (but such officer coming on board by a brow is not piped unless arriving at a prearranged time);

the President or a member of a court-martial proceeding to or returning from the court;

the Officer of the Guard when flying a pendant;

a body when being brought on board or sent out of a ship.

NOTE. All officers of the Royal Navy in uniform, irrespective of branch, are piped aboard foreign warships.

The side is piped when the officer arrives and again when he leaves. It is piped twice on each occasion—once when his boat approaches or leaves the gangway and again as he ascends or descends the accommodation ladder. When an officer arrives or departs by a brow he is piped once only, as he crosses the brow.

The side is not piped at any shore establishment.

GUN SALUTES AND FIRING OF GUNS

The regulations for gun salutes are laid down in *The Queen's Regulations for the Royal Navy*. The more general occasions on which gun salutes are fired are:

(i) anniversaries of the actual date of the Birthday, Accession, and Coronation

of the Sovereign; also H.M. the Queen's official birthday (as notified in the *London Gazette*);

(ii) birthdays of H.R.H. Prince Philip the Duke of Edinburgh and Her Majesty Queen Elizabeth the Queen Mother;

(iii) at visits by the Sovereign or members of the Royal Family to ports or to H.M. fleets or ships;

(iv) when H.M. ships meet with the Sovereign or with any member of the Royal Family at sea;

(v) on occasions similar to those in (iii) and (iv), but in regard to the heads of foreign states;

(vi) on arrival of one of H.M. ships at a foreign port as a National salute, and also in honour of the senior foreign Flag Officer present (if any);

(vii) when any of H.M. ships meets a foreign Flag Officer at sea (unless H.M. ship is wearing the flag of an officer senior to him);

(viii) by the next senior officer present when a Flag Officer hoists his flag on assuming command;

(ix) by a ship, or by the senior of two or more ships, when first meeting a Flag Officer at sea or in harbour after the latter has assumed his command;

(x) when H.M. ships are visited on official occasions by British or foreign personages, or by Military or Air Force officers who are entitled to a salute;

(xi) at the funerals of high-ranking officers.

It used to be the custom when at sea for the saluting ship to turn and head towards the ship being saluted. This originated in the days when ships were armed with broadside guns only and the salutes were fired with shotted rounds; by heading towards the other ship the salute could not be mistaken for an act of aggression. This custom, however, is not observed nowadays.

Royal and national salutes are of 21 guns. The number of guns for other salutes varies from 21 (e.g. for a Governor-General) to 7 (e.g. for a Consul). (Some Middle Eastern authorities are entitled to a smaller number of guns.) A salute to a national flag, or to the flag of a foreign Flag Officer, is returned gun for gun. A salute by one of H.M. ships to the flag of a British Flag Officer is returned by the number of guns to which the officer initiating the salute is entitled; although officers of the rank of Captain and Commander are not entitled to a gun salute, they are in this respect entitled to a return salute of 7 guns. No other gun salutes are returned.

On occasions of visits to ships by royalty, heads of states and naval boards of the Commonwealth, salutes are fired when they go on board and again when they leave the ship. Salutes to personages other than those mentioned above are fired once only, either when they go on board or when they leave the ship.

Salutes at funerals

Minute-guns are fired at the funeral of an officer entitled to a gun salute, between the time his body leaves the ship or place where it has been lying and the time it is buried; in the case of royalty the guns are fired at three-minute intervals. A salute is also fired after the burial, and in each case the number of guns is limited to that to which the officer was entitled when alive.

At the funeral of a Captain or Commander in command of a ship seven minute-guns and a salute of seven guns are allowed from the ship the officer commanded.

At the funeral of all officers and men three volleys of musketry are fired over the grave (or over the body when committed to the sea) and the 'Last Post' is sounded.

Only ships commanded by a Captain or Commander, and equipped for saluting, are authorised to fire salutes.

Times of firing salutes

The general rule is that salutes shall be fired only between 0800 and sunset, except on Sundays when they shall be fired only between 0800 and 1030, and 1300 and sunset. Noon on weekdays is the time laid down for firing salutes in honour of royal anniversaries. If the occasion falls on a Sunday the salute is fired at noon on the following day.

Flag hoisted during gun salutes

For royal salutes and salutes to national flags the appropriate standard or flag is broken at the main masthead. For other personal salutes the appropriate flag is broken at the fore masthead. The standard or flag is broken with the first gun of the salute and hauled down immediately after the last gun.

Logging salutes

All gun salutes and official ceremonies are entered in the ship's log.

Court-martial gun

In a ship in which a court-martial is to be held a gun is fired, and the Union Flag is hoisted at the peak, at the time of 'Colours' on each day on which the court sits. The Union Flag is hauled down when the court adjourns for the day or disperses, and when more than one court-martial is held on the same day it is dipped between each separate court.

MILITARY HONOURS

These include the parading of guards and bands, and as a rule these honours are only paid, in part or in whole, to dignitaries who are entitled to a salute of 11 guns or more (that is to certain dignitaries of and above the equivalent rank of a Commodore or a Brigadier). No military honours are paid to civilians or church dignitaries, except to diplomatic agents of the Pope who, as Head of the Papal State, is regarded as a foreign sovereign.

Guards

Guards are only paraded for royalty, foreign sovereigns and heads of states and persons holding military rank. They are known as 'Guards of Honour' and vary in size with the importance of the person for whom they are paraded. A

Royal Guard consists of a lieutenant-commander or lieutenant, one other commissioned officer, four P.O.s, 96 men and a bugler.

Bands

Musical salutes are only accorded to those persons who are entitled to be received by a guard. The playing of musical salutes appears to be of comparatively recent origin, especially if the selection of tunes is taken as an indication of the age of the custom. In 1841 the customary salute to officers of high rank on board H.M. ships was the beating of drums.

The Sovereign is saluted with the National Anthem in full. Other members of the Royal Family, Governors-General and the Governor of Northern Ireland are saluted with the first six bars of the National Anthem. (At shore establishments abroad the rules are slightly different.)

Foreign sovereigns and presidents of republics are saluted with the national anthems of their respective countries.

Other officers and dignitaries are saluted by the playing of specified tunes.

Hours during which guards and bands are paraded in harbour

Weekdays: from 'Colours' to noon (except Saturdays), and from 1315 to sunset or 1800, whichever is the earlier; or, when a two-hour dinner hour is in force, from 1400 to sunset or 1800, whichever is the earlier.

Sundays: from 'Colours' to 1200 (except during divine service).

Exceptions: (i) guards and bands are not paraded from one-and-a-half hours before carrying out general drill until one hour after general drill is completed.

(ii) When proceeding into or out of harbour, or when passing or being passed by a royal or other personage in a ship or boat, or when receiving such personages on board, guards and bands are paraded at any time from 'Colours' to sunset (or 1800) on weekdays, and from 'Colours' to noon on Sundays.

(iii) In foreign ports, or in British ports when distinguished foreign visitors are received on board, guards may be paraded after 1800.

NOTES

(i) An officer of flag rank or a Commodore not entitled to wear a flag or broad pendant does not receive a gun salute, but he does receive the other military honours due to his rank.

(ii) An administrative officer (e.g. a Governor), if he is also an officer of flag rank is entitled to the full military honours and marks of respect appropriate to his naval rank, if he is in naval uniform. If he holds other military rank he is entitled to the military honours of that rank.

(iii) Army and Air Force officers of, and above, the rank of Brigadier and Air Commodore are entitled to the same military honours as their equivalent ranks in the Royal Navy. They do not receive the pipe.

(iv) If no band is available for receiving a Flag Officer the 'General Salute' is sounded on the bugle instead of the appropriate musical salute, and similarly the 'Commodore's Salute' is sounded for a Commodore.

(v) Captains and Commanders in command of ships are entitled to a return salute of seven guns.

(vi) Foreign officers of military, diplomatic, or administrative services receive the same honours as their equivalents in the British Services.

(vii) At the discretion of the Senior Officer, other distinguished persons may be received with the 'Alert'.

CEREMONIAL RECEPTION

The following description of the ceremonial attending the reception of personages on board one of H.M. ships is given as a general guide.

Fifteen minutes before the expected time of arrival, 'Guard and band' and 'All buglers' are sounded, and the Ceremonial Piping Party is piped to muster. (When appropriate this party should comprise the Boatswain, Chief Boatswain's Mate, Chief Quartermaster and all available quartermasters and boatswain's mates.)

If a gun salute is to be fired, 'Saluting guns' crews' is sounded; the Gunner is informed of the number of guns for the salute, and the Communications department prepares the flag to be broken at the masthead with the first gun. The 'Commence' is sounded on the bugle as the signal for the first gun to be fired.

As soon as the boat conveying the personage is sighted, or known to be on its way, the Captain and the Executive Officer are informed, the quarterdeck is cleared and the side is manned.

At the order 'Man the side' the ceremonial piping party is mustered in two or three ranks athwartships and just before the gangway. Two of the gangway staff man the lower platform of the accommodation ladder to hand the manropes and assist the personage and his retinue out of the boat, and another, stationed before the piping party, mans the gangway boatrope. The Officer of the Watch supervises proceedings from the upper platform of the accommodation ladder until the personage has left his boat. The guard is drawn up fore-and-aft, abaft the gangway, clear of the side and facing outboard; and the band is drawn up abaft, and in line with, the guard.

When the boat is two or three lengths from the accommodation ladder the 'Alert' is sounded and the guard comes to the 'Slope' (or the 'Shoulder' if awnings are spread). This is followed by the first pipe if the personage is entitled to one. The second pipe is timed so that it ends as the personage reaches the upper platform of the accommodation ladder. Any accompanying retinue do not leave the boat until the personage has been received on board. All members of the reception party come to the salute during each pipe; the ceremonial piping party, however, do not salute. As soon as the personage steps aboard, the guard comes to the 'Present' and the band plays the appropriate musical salute, after which the guard returns to the 'Slope' (or 'Shoulder') and the members of the reception party return from the salute. The officer commanding the guard then reports his guard to the personage if he is of senior

relative rank to the officer receiving him, and the personage may then inspect the guard; if, however, the personage is of junior relative rank to the officer receiving him, the guard is not reported to him, nor does he inspect it. If a salute is to be fired it can be fired immediately before the personage arrives if his time of arrival has been arranged beforehand, or immediately after his boat has left the ship. The 'Commence' is sounded before the gun salute, the 'Cease fire' after it, and after a suitable pause the 'Carry on' is sounded.

The ceremonial on leaving is very similar, and is carried out in the order: 'Guard and band', 'Man the side' (any accompanying retinue proceed into the boat), 'Alert', 'Present arms' (reception party come to the salute) 'Musical salute', 'Slope' (or 'Shoulder') arms, 'First pipe' (if accorded), 'Second pipe' (starting as the boat leaves the accommodation ladder), reception party return from the salute. If a gun salute is to be fired the 'Commence' is sounded when the boat is lying off clear of the line of fire. The 'Carry on' is not sounded until the boat clears either the stem or stern of the ship on her return trip.

Between the sounding of the 'Alert' and the 'Carry on' all hands on deck stand to attention and face outboard, and boats under way stop engines or lay on their oars or let fly sheets, according to the type of boat.

SALUTES BETWEEN SHIPS

When a ship enters or leaves harbour between sunrise and sunset all hands on deck should be dressed in the correct rig and fallen in, all boats (except seaboats on radial davits) should be turned in, weapons correctly trained and laid, the ship's sides clear, and ropes and rigging neatly stowed and secured. Between 'Colours' and sunset or 1800 (whichever is the earlier) the lower deck is cleared, the ship's company is mustered at stations for entering and leaving harbour, and guards and bands are paraded.

When two men-of-war pass one another between sunrise and sunset the following salutes are exchanged:

When only one ship is under way, and when either ship is wearing a royal standard, flag, or broad pendant, or when the other ship is a foreign man-of-war. The junior ship sounds the 'Alert' on the bugle, which is answered by the senior ship sounding the 'Alert' on the bugle. All the ship's company on deck in both ships come to attention and face outboard, and the senior officer on board the junior ship salutes, this salute being returned by the officer being saluted in the senior ship. If the occasion is one on which guards and bands parade, the guard of the junior ship presents arms and her band plays the appropriate musical salute. Such military honours are received with the guard of the senior ship at the slope. After a short interval the senior ship sounds by bugle the 'Carry on', this being followed by the junior ship also sounding the 'Carry on'.

NOTES

(i) If a bugle is not available the 'Still' is piped on the boatswain's call, or blown on a whistle, instead of the 'Alert' being sounded.

(ii) If a band is not available the 'General Salute' is sounded on the bugle in place of any musical salute. If a bugle is not available the salute is given in silence.

(iii) Whenever the bugle is available it is used in giving or returning the salute.

(iv) When the other ship is a foreign man-of-war and doubt arises as to which is the senior ship, Her Majesty's ship should be ready to initiate the exchange of salutes.

When only one ship is under way, and when neither ship is wearing a royal standard, flag, or broad pendant, and when the other ship is not a foreign man-of-war. The bugle is not used, but similar marks of respect are accorded and returned by pipe or blown on the whistle. If guards and/or bands are paraded the guards remain at the slope and no musical salutes are accorded.

The 'Alert' sounded on the bugle is a mark of respect due to rank, and is accorded only to those persons so entitled.

In all cases when both ships are under way. The salute is made and returned by pipe, or blown on the whistle; bugles are not sounded. If guards are paraded they come to the slope only, and if bands are paraded no musical salutes are accorded.

If the other ship is a foreign man-of-war and appears likely to sound the 'Alert' and accord other military honours, reciprocal action should be taken by H.M. ships.

CEREMONIAL IN BOATS

Wearing of ensigns

Boats belonging to H.M. ships or establishments wear ensigns on the following occasions when under way:

between 'Colours' and sunset whenever wearing a Royal Standard or a distinguishing flag of an authority other than a naval authority;

in foreign waters on all occasions during daylight hours;

whenever going alongside a foreign man-of-war, by day or night;

whenever H.M. ships are dressed;

whenever carrying a corpse, the ensign being then worn at half-mast.

NOTE. When the ensign is half-masted in H.M. ships, boats' ensigns (if worn) should also be half-masted.

Flying of distinguishing flags or pendants

Any of the persons authorised to fly a distinguishing flag or pendant may fly the appropriate flag (or pendant) in the bows of a boat when under way and proceeding on occasions of ceremony, such as official visits or inspections. If the person is other than a naval authority the boat also wears her ensign. Persons other than naval authorities only fly their flags in boats between the hours of 'Colours' and sunset. Although not specifically laid down, the flags of naval authorities are usually flown in boats during the hours of daylight only.

The masthead pendant is flown in a boat, under similar circumstances, by

officers holding an appointment in command of one of H.M. ships, sea-going tenders, or shore establishments.

The masthead pendant is also worn by a boat between the hours of 'Colours' and sunset if she is carrying members of a court-martial who are proceeding to or from the court. It is also worn by day and by night by a boat carrying the Officer of the Guard.

A Queen's Harbour Master or his deputy may fly his flag in the bows of a boat or vessel when in the execution of his duty.

Officers of flag rank usually have their flags painted on the bows of their barges instead of the boat's badge. Their barges can be distinguished by the colour of the hull—green for Commanders-in-Chief and dark blue for other Flag Officers.

The boats of Chiefs-of-Staff or Captains-of-the-Fleet have the flag appropriate to the Flag Officer on whose staff they are serving painted on the bows.

Displaying of indicator plates

'Indicator plates' are displayed in boats on occasions when a distinguishing flag is not worn to denote the presence of senior officers. The following are the authorised indicator plates used for this purpose:

the 'red disc', consisting of a white St. George's cross on a red background;

the 'blue disc', consisting of a white St. George's cross on a blue background;

the 'white disc', consisting of five black crosses on a white background.

All discs are 10 inches in diameter.

The *red disc* denotes that the boat is carrying an officer entitled to fly a flag or broad pendant on a formal occasion, but that the full ceremonial due to his rank is not required.

The *blue disc* denotes that the boat is carrying on a formal occasion an officer of flag rank or a Commodore not entitled to fly a flag or broad pendant. On such occasions the officer is received with the 'Alert'.

The *white disc* denotes that the boat is carrying an officer entitled to fly a flag or broad pendant on an informal occasion when only courtesy salutes are accorded.

Saluting of standards and distinguishing flags

When a boat wearing a standard or a distinguishing flag passes a ship at anchor, the ship should parade a guard and a band and accord the appropriate salute unless orders to the contrary have been given. Should the ship be wearing the flag or broad pendant of an officer senior to the officer in the boat, the guard and band are not paraded and the 'Alert' only is sounded.

If the boat passes a ship under way the ship should pipe the 'Still', and if her guard and band are paraded the guard should come to the 'Slope' and no musical salute should be accorded.

When a boat displaying the red or the blue disc passes a ship at anchor the ship should sound the 'Alert' only. A ship under way should pipe the 'Still'.

When a boat displaying the white disc passes a ship at anchor, the Officer of the Watch (or in his absence the quartermaster) should salute from the gangway.

Salutes and marks of respect

All officers when getting into or leaving a boat are saluted by the officer in charge of the boat or the coxswain.

The following rules govern the exchange of salutes between Service boats under way:

1. The officer or coxswain in charge of the boat will always salute, except that when he is in an inconspicuous position one of the boat's crew will be detailed to salute instead.
2. The senior of the officers in the boat will also salute whenever this is practicable.
3. The salute will be acknowledged by the officer being saluted, unless he details an officer or the coxswain to do so.
4. No salutes are exchanged between boats carrying officers of equal rank.

In boats other than Service boats, whether alongside or under way, officers and men should pay and return salutes as dictated by courtesy, but only the officer or man in the most convenient position should salute.

In addition to these salutes, special marks of respect are paid to royal and important personages and senior officers; these are shown in the table on page 463.

Boat hails

At night any boat approaching within hailing distance of a ship is challenged by the hail 'Boat ahoy'. If the boat is not calling alongside the hailing ship she will reply 'Passing'. If the boat is to call alongside, her reply will be governed by the rank or status of the person she is carrying, in accordance with the following table:

Person carried	*Reply*
A Royal Personage or Head of a State	'Standard'
An officer of Flag rank or a Commodore entitled to fly his broad pendant	'Flag', followed by the name of his flagship when appropriate
A Chief-of-Staff or Chief Staff Officer (when no C.O.S. is allowed) and a Captain-of-the-Fleet	'Staff' with the name of the flagship
Commanding Officer of a ship	Name of the ship which he commands
Other officers	'Ay, Ay'
Officer of the Guard	'Guard boat'
All other persons and all boats going alongside not otherwise provided for	'No, No'

Table of Special Marks of Respect to be paid in Boats

<table>
<tr><th rowspan="2">Personage to whom, or occasion on which, Marks of Respect should be paid</th><th colspan="3">Marks of Respect by boats Under Way</th><th rowspan="2">Marks of Respect by a boat alongside a Landing Place, an Accommodation Ladder, or Made Fast</th></tr>
<tr><th>Power boat</th><th>Boat under Oars</th><th>Boat under Sail</th></tr>
<tr><td>1. The Sovereign; members of the Royal Family and equivalent personages of other nations; Ambassadors, Governors-General, and their equivalents in other nations. (Standard or appropriate flag is worn by the boat.)

2. Commanders-in-Chief, Flag Officers and Commodores, and their equivalents in other Services and nations, when flying the appropriate flag of their command in their barges or boats.

3. A boat containing a Service funeral party with the body. (Ensign at half-mast is worn by the boat.)

4. During the hoisting and lowering of colours in harbour, and during the firing of gun salutes.</td><td>Stop Engines</td><td>Double-banked boats: Toss Oars

Single-banked boats: Lay on Oars</td><td rowspan="2">Let-fly Sheets</td><td rowspan="2">Crew called to attention (see notes (ii), (iii), (iv) and (v))</td></tr>
<tr><td>5. Commanders-in-Chief, Flag Officers, Commodores, Commodores and above holding staff appointments, and officers or personages of equivalent rank in other Services or nations, when displaying a red or a blue disc in the boat.

6. Commanders-in-Chief, Flag Officers, Commodores, and officers of equivalent rank in uniform or plain clothes, when displaying a white disc in the boat.

7. Any British or foreign naval officer flying a pendant in a boat.</td><td>Reduce speed to Slow</td><td>All types of boats: Lay on Oars</td></tr>
</table>

Notes:

(i) Marks of respect are paid in all boats on occasions (3) and (4); otherwise only in boats in which officers junior to the personage or officer passing are passengers.

(ii) In decked-in power boats, members of the crew who are not engaged in keeping the boat alongside, and all passengers, stand to attention and face in the direction of the personage or officer being saluted.

(iii) In open boats of all types, members who are not engaged in keeping the boat alongside, and all passengers, sit at attention.

(iv) Boatkeepers sit at attention and the senior rating in the boat salutes.

(v) The executive order for calling the crew and passengers of a boat to attention is 'Boat's crew'. The customary attitude of attention when seated in a boat is sitting upright and squarely on the thwart or bench, with arms folded.

(vi) It is the custom in the Royal Navy for a boat to avoid crossing close ahead of any boat which is carrying an important personage or a senior officer, even if the former boat has right of way by the Rule of the Road.

STANDARDS, FLAGS AND PLATES IN CARS

If a car conveys a royal or other personage on ceremonial or official occasions the appropriate standard or flag, in minature, is flown on the front of the vehicle, and the salute necessary to the occasion should be accorded.

Star plates may be displayed on cars carrying officers of Flag rank, Commodores, and Royal Marines officers of equivalent rank. The number of white six-pointed stars on a royal blue background (for R.N. officers) or on a red background (for R.M. officers) is as follows:

Admiral of the Fleet	5
Admiral; or General, Royal Marines	4
Vice-Admiral; or Lieutenant-General, R.M. ..	3
Rear-Admiral; or Major-General, R.M. ..	2
Commodore; or Brigadier, R.M.	1

PART IV

SHIPHANDLING AND NAVIGATION

CHAPTER 15

Measurement of Speed, Distance and Depth

Sea measurements

1 fathom = 6 feet or 2 yards
1 cable = 608 feet, or roughly 200 yards or 100 fathoms
10 cables = 6,080 feet or 1 sea mile, or roughly 2,000 yards
1 sea or nautical mile = 6,080 feet, or roughly 2,000 yards
1 league (obsolete) = 3 sea miles
1 knot = 1 sea mile per hour

Dutchman's log

This is probably the oldest and simplest method of measuring the speed of a ship. A hand is stationed in the eyes of the ship with several pieces of wood, and at intervals he throws one overboard so that it will float aft well clear of the ship's side. Two observers are stationed, one forward and one aft, as far apart as possible, and the distance between them is accurately measured. The length of time which each piece of wood takes to pass from one observer to the other is accurately noted by stop-watch, and the speed of the ship is then calculated with reasonable accuracy from the mean of five such intervals.

EXAMPLE

Distance between observers is 420 feet;
Mean interval of time for 5 runs is 35 seconds;

$$\text{Speed of ship} = \frac{420}{35} \times \frac{60 \times 60}{6{,}080} = 7 \cdot 1 \text{ knots.}$$

Estimation of speed by revolutions

The speed of a power-driven ship can be estimated from the number of revolutions of her propeller shafts during a given interval of time. A table, known as the *revolution table*, is made out for each ship from the results of trials. It gives the revolutions per minute of the propeller shafts required for each knot of the ship's range of speed in smooth water, when the draught of the ship is normal and the bottom clean. The ship's speed is usually estimated from the mean revolutions per minute during one hour's steaming. These tables are a good guide for estimating the speed through the water if allowances are made for any variation from normal draught, the state of the ship's bottom, and the effect of wind and sea, but it is usually easier to estimate these allowances accurately for a large ship than for a small one.

TOWED LOGS

The principle on which these logs work is that, when towed through the water, a specially constructed *rotator* will revolve at different rates at different speeds

of tow. The revolutions of the rotator are transmitted by the log line to a counter mechanism which registers the distance run.

There are several types of this log in use at sea, but the one described here and illustrated in fig. 15–1 is the Trident Log, which is still supplied to a few ships of the Royal Navy.

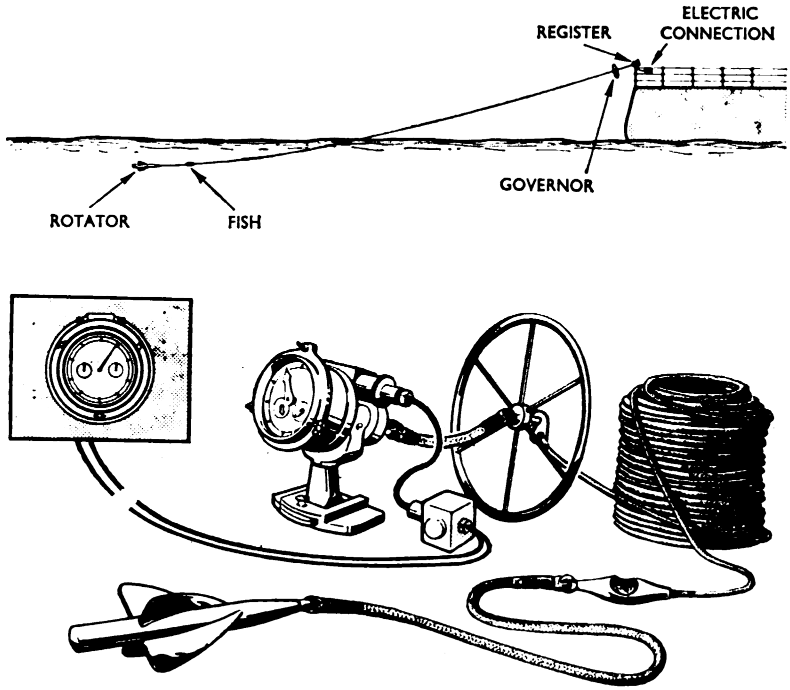


FIG. 15–1. Towed log (Trident type)

Trident log

This log has a four-bladed bronze rotator at the head of which is a fixed eye connected by the log line to the counter mechanism (called the *register*), which is usually situated right aft and mounted on a guardrail stanchion or on the taffrail. The register is electrically connected to a repeater, usually situated in the chart house.

The register and the repeater are equipped with similarly graduated dials and pointers. The large dial records the distance run in miles, from one to 100; one of the small dials records tenths of a mile run, and the other records hundreds of miles run, from 100 to 500.

The log line is $1\frac{1}{8}$-inch special plaited line, supplied ready for use, and fitted with a hooked eye at one end and with the other end bare, in lengths of 70, 65, 50 and 40 fathoms. Between the register and the log line is fitted a wheel (called the *governor*), which is fitted with a short length of 2-inch special plaited line with a hooked eye at its foremost end. The governor with its line is hooked into

the eye of the register, and the eye of the log line is hooked into the eye of the governor. The after end of the log line is passed through the end of a special link (called a *fish* or a *shell*) and then out through a hole in its barrel; it is secured from unreeving with a figure-of-eight knot which is then tucked back into the barrel of the fish. The barrel is grooved inside to prevent the line from turning. The rotator is connected to the fish by a short length of 2-inch plaited line, spliced at both ends and supplied ready fitted. The fish thus enables the length of the log line to be adjusted without interfering with the spliced end.

The accuracy of these logs depends largely on the depth at which the rotator is run, and therefore upon the speed of the ship and the length of the log line. The following lengths of log line have been found suitable:

40 fathoms at speeds of about 10 knots

50-55 fathoms at speeds of about 15 knots

65-70 fathoms at speeds of about 18 knots and over.

These logs will not register accurately at slow speeds and they are therefore not streamed until the ship is clear of harbour; their accuracy varies also with the type of ship. For these reasons their individual errors must be recorded for varying speeds by trial either from a run between two points at a known distance apart, allowance being made for the tidal stream or current; or from a run over a measured distance, with and against the tidal stream or current.

The log line is liable to stretch appreciably, and should therefore be frequently measured. Because of its plaited construction, deterioration is difficult to detect and the line should be carefully inspected from time to time.

If the log under-records for no apparent reason it is a sure sign that it is foul or has been damaged, and it should at once be handed. Great care should be taken of the rotators, especially when streaming or handing the log, as any distortion may considerably affect the accuracy of the log.

The disadvantages of this type of log are that the rotator is liable to be fouled or damaged by flotsam; it must be handed if the ship stops or goes astern; it is inaccurate in a heavy following sea; and it attracts large, predatory fishes in tropical waters.

To stream the log. Ship the register, set the pointers to zero, and connect up the electric cable from the deck connection. Hook the governor to the register, tail forward. Select the correct log line for the ship's speed and hook its forward end to the governor. Lead the log line, from outboard, in through the after fairlead, fake it down along the poop or quarterdeck in as long fleets as possible, and secure it to the link and rotator. The log should not be streamed or handed at speeds of over 10 knots, otherwise the strain on the line becomes too great; and it should always be streamed from the windward quarter. To stream the log, pass the rotator out from the fairlead, lower it into the wake, and then pay out the log line, keeping it under control and taking care that no undue strain is placed on the register or its mounting.

To hand the log. Before starting to hand the log, note the time and the reading of the register. Stop the governor, grasp the log line abaft it, and recover a sufficient amount to pass the bight through the fairlead and belay it on the bight. Disconnect the log line from the governor, and the governor from the register. Then run the log line in, veering the first end astern from the opposite

fairlead at the same time to take the turns out of the log line. Recover the rotator with care and then haul in the log line streamed from the opposite fairlead. Wash the rotator in fresh water, dry it and smear it with light oil, wipe over and dry the governor and register before stowing them away, and stop up the log line in bights to dry.

BOTTOM LOGS

Bottom logs project through the bottom of the ship and measure either the speed of the ship through the water from the pressure of water (pitometer log) or the distance run through the water (Chernikeeff log), or both electrically (electro-magnetic log).

Pitometer log

The logs supplied to H.M. ships by the British Pitometer Log Co., Ltd., London, are 'pressure-type' logs, i.e. they depend on the difference between the normal pressure ('static' pressure) of water resulting from the depth of the instrument protruding through the hull of the ship, and the pressure ('impact' pressure) due to the movement of the ship through the water.

Type D (fig. 15–2). The hull fitting consists of a rodmeter, projecting about 3 ft below the hull when in the operating position, sited near the pivoting point of the ship. When housed, the rodmeter slides up through a watertight gland, withdrawal being prevented by stops, and the opening in the hull can be closed below the rodmeter by a sluice valve. The rodmeter is a hollow bronze rod of oval cross-section, having a flat end containing one 'impact' orifice facing forward and two cross-connected 'static' orifices, one on each side. The impact and static orifices communicate with separate holes running lengthwise through the rodmeter to two cocks and thence by pipes to the bellows-type differential unit and controller, which converts the difference of pressure into speed for the speed and distance transmitter.

The transmitter contains a motor driving the disc of a potter's wheel at a fixed rate (i.e. a certain number of revolutions in a fixed *time*). The potter's wheel converts *speed* (the position of the roller) into *distance*, which is transmitted, with the speed, to speed indicator and distance registers in other parts of the ship.

*Type M.A.*3 (fig. 15–3). The main difference between this and the Type D log is that the differential unit is mercurial and the differential and controller are mounted in gimbals.

The tubes (*D* and *E*) are part-filled with mercury. Above the mercury the tubes, differential, connecting tubes and rodmeter tubes are open to the sea. The impact orifice (*A*) is connected to the outer mercury tubes, the static orifice (*B*) to the float chamber (*C*). A weighted float (*F*) rests on top of the mercury and carries a bronze rack which engages with a gear wheel to operate the master speed scale (*G*) of the controller.

After trials the errors of the log can be corrected by a cam in the controller. In some ships more errors are introduced when retractable underwater projections, such as the sonar dome, are extended. A special cam can then be

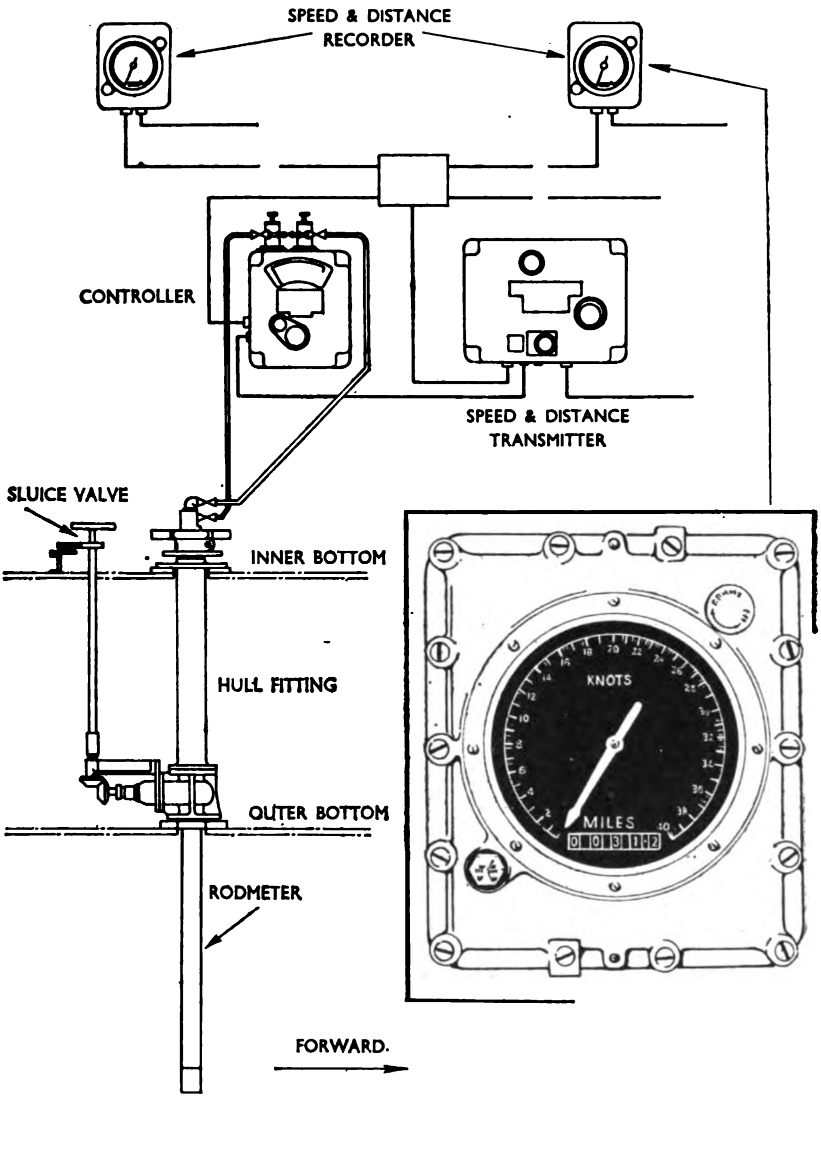


FIG. 15-2. Type D pitometer log

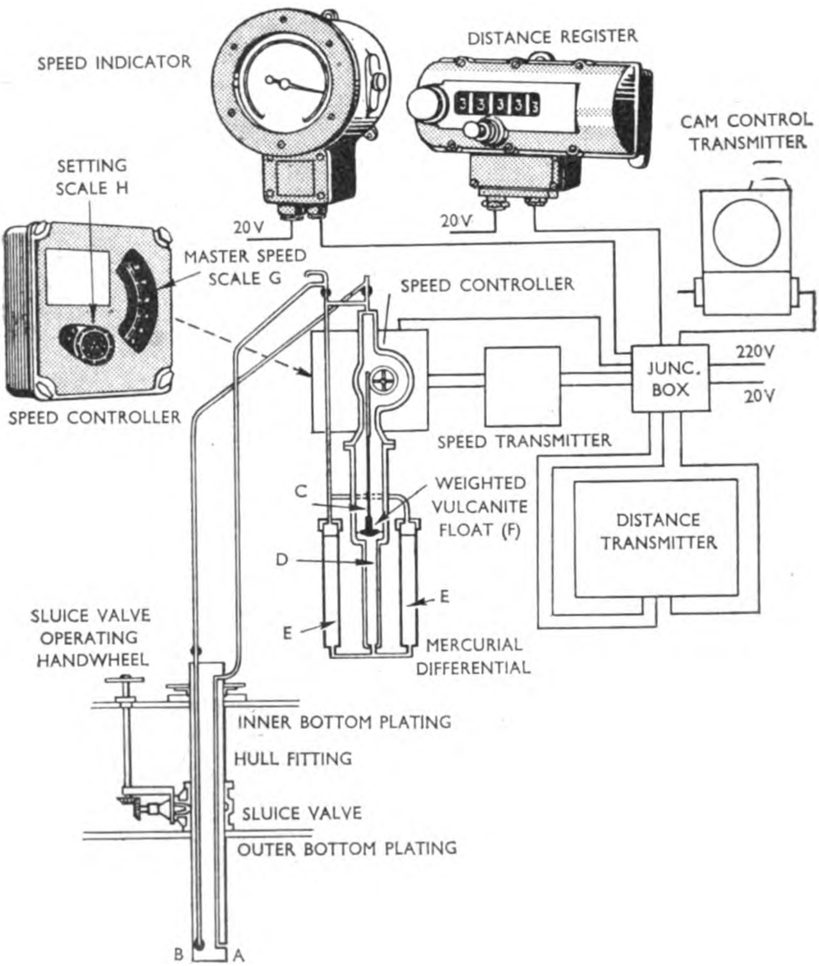


FIG. 15–3. Type M.A.3 pitometer log

brought into use by the cam control transmitter, usually situated on the bridge.

Chernikeeff log (fig. 15–4)

An impeller is fitted on the lower end of the rodmeter, which can be projected about 1½ ft below the hull of the ship. The impeller is rotated by the flow of water; it operates a submerged make-and-break mechanism, which works in oil inside the shaft. This mechanism transmits impulses electrically to the distance recorder, situated in some convenient position in the ship. The log thus primarily measures distance.

Water cannot enter the mechanism because oil inside the shaft is maintained at a higher pressure than that of the sea surrounding it, by means of an oil-injector operated by a handwheel. Owing to the very small clearance between the impeller shaft and its bearings, loss of oil to the sea is negligible.

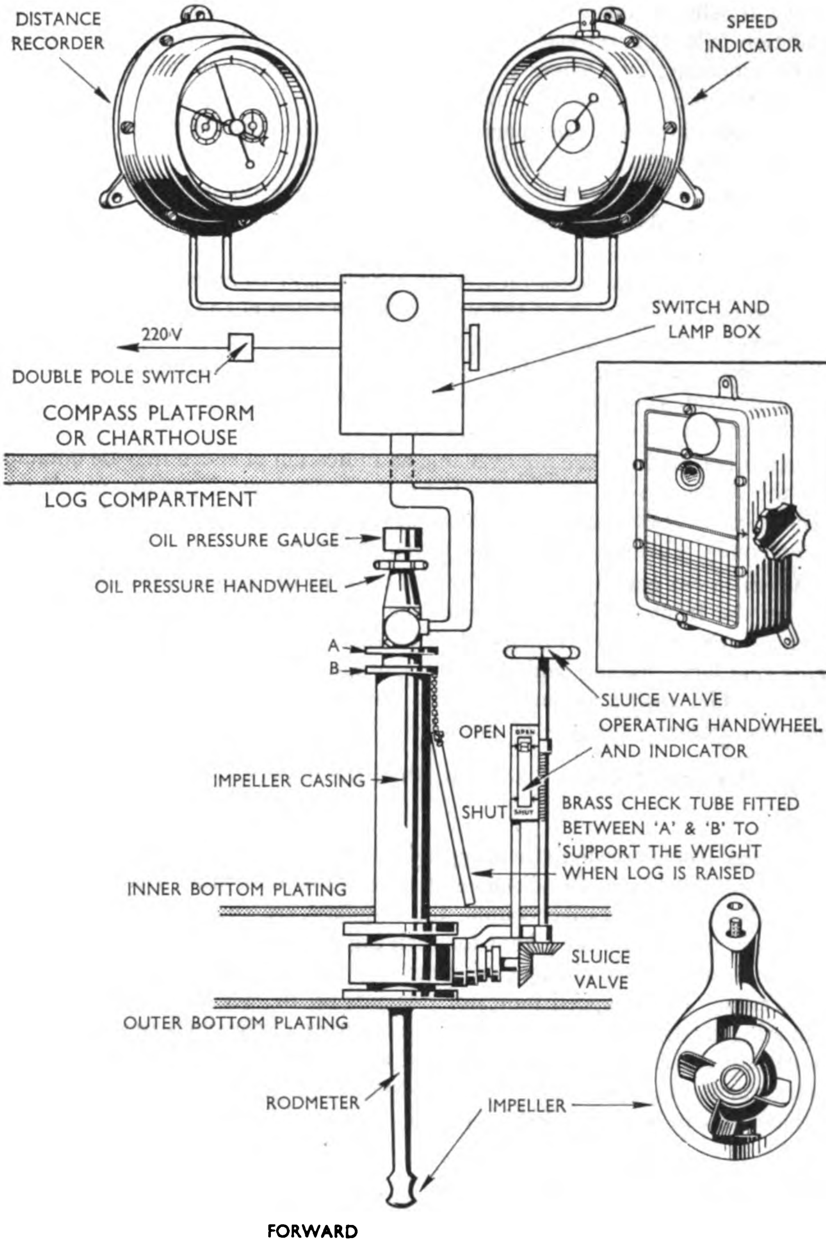


FIG. 15–4. Chernikeeff log

If the impeller mechanism is not kept in order and perfectly clean, the whole installation fails. It is retracted into the ship by raising the shaft bodily; it can then be supported by a 'check tube.' A sluice valve can then be closed and the log shaft removed from its housing.

The make-and-break mechanism, operated by the impeller, transmits impulses every 1/400 mile to the distance recorded.

The *distance recorder* consists of a dial with four pointers. The large red pointer indicates fractions (to the nearest 1/400) of a mile on the outer scale; one complete revolution of this pointer corresponds to one mile. The large black pointer indicates miles on the inner scale and completes one revolution every 100 miles. The scale of the small left-hand dial is 100 miles per division (1,000 miles for one complete revolution), while the scale of the small right-hand dial is 1,000 miles per division. The master distance recorder controls, by make-and-break contacts, the distance recorder repeaters, the master speed indicator and the speed indicator repeaters.

When other methods are not available an indication of speed may be obtained from the distance recorder by the following procedure: Note the number of divisions (miles) of the inner scale over which the red pointer moves in a period of 36 seconds. This will indicate the speed in knots.

The *switch box* contains a switch which controls the speed indicator. A speed table on the front of the box and a blue flashing lamp provide a secondary means of calculating the log speed. The time, in seconds, is taken between twenty-one lamp flashes, and the corresponding speed can be obtained from the table. The flashes are made by the impeller make-and-break mechanism. Therefore, between twenty-one flashes the log has run 20/400 mile, and if, for example, the time taken is 6 seconds, then the log speed is $\frac{20 \times 3{,}600}{400 \times 6}$, or 30 knots.

The *speed indicator* calculates the speed according to the number of 1/400-mile impulses received from the distance recorder in a fixed time. With a 5-second interval between successive counts, the impulses are counted for a period of 18 seconds and the speed, $\frac{1}{2}$ knot for each impulse, indicated on the dial of the speed indicator. Thus changes of speed are indicated at 23-second intervals. The accuracy of the speed indicator depends on the accuracy of the impeller originating the distance impulses and the accuracy of the clock mechanism, the latter being enhanced by the short period of time involved and the fact that the clock error is not cumulative. Any number of speed indicators, without clock mechanism, can be controlled by the master speed indicator.

The electro-magnetic log

This log consists of a rodmeter, fitted in the hull of a ship in a similar manner to the rodmeter of a pitometer log, and a master speed and distance transmitter housing the electronic and electro-mechanical equipment. Connection between the rodmeter and the master speed and distance transmitter is by two screened cables.

An iron-cored coil mounted in a fibre-glass shell is fixed at the lower end of the rodmeter. The coil is supplied with alternating current and will, when moved through the water, produce a voltage in the water surrounding it. The

voltage, proportional to the flux and the relative velocity of the rodmeter to the water, is picked up by two electrodes on the rodmeter and applied to the electronic circuits in the master speed and distance transmitter, where it is converted into speed and distance. Various elements can be fitted in the transmitter and an associated ship's speed retransmission unit to enable any kind of transmission for speed and distance, or pulse for distance, to be connected to remote indicators and other equipment.

RANGING AND STATION-KEEPING INSTRUMENTS

These are hand instruments generally used on the bridge for obtaining ranges of navigational marks and nearby ships, for navigation and station-keeping purposes, respectively.

They comprise Stuart's distance meter, the Waymouth-Ross sextant rangefinder, the Husun Marine distance meter and the Small-base rangefinders. Stuart's distance meter is described below; descriptions of the others are given in the *Admiralty Manual of Navigation* and in the maker's instructions supplied with the instruments.

Stuart's distance meter

This instrument (fig. 15–5) provides a means of measuring the range of an object of known height at ranges between one-quarter of a cable and about 15 cables. Although the scale is graduated above this range, higher readings cannot generally be considered reliable. The instrument consists of a long, curved lens (*A*), attached to a radial distance scale, which is graduated from one-quarter of a cable to 30 cables. Both this lens and the scale are mounted in a slide which can be moved up and down inside the frame of the instrument. A pinion carried on the spindle of a milled knob (*B*) engages a rack to provide this movement.

A fixed wedge-shaped lens (*C*) is mounted, alongside the moving lens, on the frame of the instrument. A small telescope fitted with an interrupted thread can be inserted in the metal collar (*D*). The telescope should be focused after being fitted in the instrument. The object, when viewed, appears as a superimposed image.

Across the movable distance scale is a fixed horizontal metal bar. This is the height scale; it is graduated from 0 to 220 ft. On this bar is a sliding pointer. On the reverse side of the instrument is a blank table for inserting, in pencil, the required data concerning ships likely to be in company.

Operation. To obtain a range, set the height above the waterline of the target against the left edge of the sliding pointer. By turning the milled knob, bring the top of one image in line with the portion of the waterline which is immediately beneath the target in the other image. The distance in cables is then read against the index mark on the sliding pointer.

The instrument can also be used to measure the range of an object of negligible or unknown height. To do this, set own height of eye on the instrument and, by rotating the milled knob, bring the waterline of the object in one

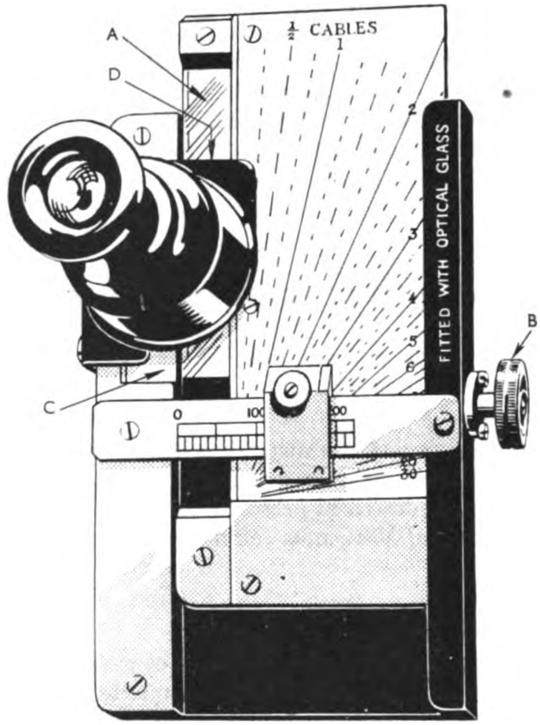


FIG. 15–5. Stuart's distance meter

image up to the horizon in the other image. The error involved in this method is about 3 per cent of the range measured.

ECHO SOUNDING

Although depths can be measured by hand lead at slow speed, H.M. ships are no longer fitted with chains and the lead is used only to give an indication of the ship's movement when anchoring and getting under way. Wire sounding machines, although still fitted in some ships, are no longer used for sounding.

The echo sounding machine is now fitted in all ships and a number of boats, such as surveying boats. The earlier sets were sonic, whereas Type 765 and later sets are supersonic and may be compared to a sonar set arranged to work vertically instead of horizontally. A brief description of Type 765 is given below.

Basic principles. A ship transmits an underwater sound impulse which travels outwards through the sea at uniform speed. On reaching the sea-bed, part of the sound impulse is reflected and returns to the ship, where its arrival is recorded graphically. The velocity of sound in sea water is known; the interval between transmission and reception is proportional to the depth of water; therefore the depth can be determined.

In shallow water this interval is extremely short: for example, the overall time is only about 1/40 second in 10 fathoms. It is not possible to measure this by

direct means, so the echo sounding machine provides a magnified time scale upon which these shallow soundings can be measured.

Outline of operation

A constant speed motor in the *recorder* drives a stylus across a slow-moving sheet of chemically-impregnated paper at a speed proportional to the speed of sound in sea water. On each revolution of the stylus a transmitting cam on the stylus shaft opens a contact which triggers the *contactor unit* and a high energy current impulse is fed to the *transmitting transducer*. The transducer vibrates and emits a supersonic signal, which is directed downwards through the ship's hull plating, then reflected from the sea-bed and creates a vibration in an exactly similar transducer called the *receiving transducer*. The electrical impulse generated in the receiving transducer is amplified and rectified in the *amplifier* and fed as a d.c. marking voltage to the recorder stylus, which has now traversed the paper a distance proportional to the depth of water. The stylus produces a brown stain on the paper at the moment of transmission and again on receiving the returned echo. The depth can be read from a Perspex scale placed vertically in front of the paper.

Transducers. Transmitting and receiving transducers are identical. Each is mounted in a heavy cylindrical tank filled with fresh water and secured to the inside of the ship's plating. These 'magneto-striction' transducers consist of a pack of thin nickel laminations with coils running through them and a parabolic reflector to concentrate the supersonic transmission. When the laminations in the transmitting transducer are subjected to a strong surge of current from the contactor unit, fed through the coils, they contract, start to vibrate and give off sound waves of 14·25 kc/s that are directed vertically downwards in a beam by the parabolic mirror. Some of these waves, reflected from the sea-bed, enter the receiving transducer and are concentrated by the reflector on to the nickel laminations, which vibrate and produce electrical oscillations in the surrounding coils. These oscillations are then amplified and rectified to produce the d.c. marking voltage for the stylus of the receiver.

When magneto-striction transducers are used as receivers, the nickel laminations have to be maintained in a magnetised condition. This is done periodically by passing a heavy unidirectional current, controlled by the flashing unit, through the windings of the transducer; the procedure is given in the handbook for the set.

Amplifier. Sensitivity is controlled by three pre-set controls inside the amplifier. Two external controls are mounted on the front panel:

(*a*) *Auto-Manual switch*. This is a selector switch for automatic or manual control of sensitivity. It should be set to AUTO in depths of less than 30 fathoms and MANUAL in depths of over 30 fathoms.

(*b*) *Manual Sensitivity Control*. When (*a*) is set to AUTO this control should be set to MAX. When (*a*) is set to MANUAL this control should be adjusted to give the best trace.

Recorder (fig. 15–6)

As the stylus begins its traverse across the paper, the transmitter contacts

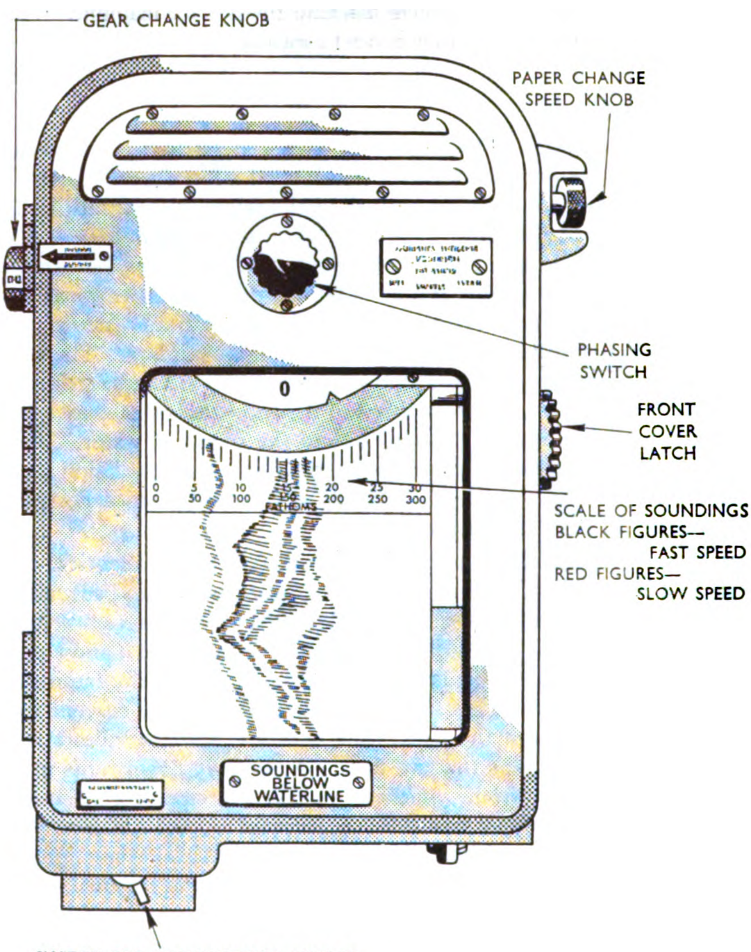


FIG. 15–6. Type 765 echo sounder recording unit

in the recorder open, and the outgoing sound makes a transmission mark near the left edge of the paper. There is a slight delay, called 'contactor lag', between the opening of the contacts and the emission of the sound; the contacts are adjusted to allow for this. The transmission mark should normally be aligned to the depth of the transducers, as indicated on the scale, so that the returning echo will show the true depth below the waterline. Should it be aligned to zero on the scale, the echo will record the depth below the keel. Whichever method is used, a notice must be fixed to the recorder stating whether the instrument is set to read depths below waterline or below keel.

The transmission is controlled by an On-Off switch at the base of the recorder.

Gear change control gives a fast and slow speed of the stylus, thereby changing the range of soundings that can be obtained in one traverse over the paper.

Phasing. When it is desired to expand the range of the recorder without

altering the scale or slowing up the movement of the stylus arm, the timing of the transmission relative to the position of the stylus can be advanced a known interval corresponding to a known depth. This is known as 'phasing', and the 'depth' by which the transmission is advanced is added to the depth shown on the scale to obtain the true sounding. A phasing switch on the outside of the recorder rotates the phasing dial mounted on the spindle on which the transmitting contacts are carried. A movement of the dial clockwise, i.e. counter to the rotation of the stylus, advances the moment of transmission by four specified 'depths', the amount being shown on the edge of the phasing dial that is visible through a large window in the front of the recorder.

If the phasing dial is turned when the recorder is switched off *it must be turned clockwise*, otherwise the transmission contacts will be damaged.

Scales. The Perspex scale for recorders with 20 or 200 fathom phasing steps are engraved with two ranges:

0–30 fathoms, in black, showing steps of 5 fathoms, further divided to show single fathom steps,

0–300 fathoms, in red, showing 50-fathom steps.

Paper. The roll of impregnated paper is housed in a tank, the hinged lid of which forms the contact surface over which the paper and stylus pass. The speed of the paper can be varied by the *paper change speed knob.* When the knob is out the speed is constant at 0·2 in./min. When pushed in, the speed is related to the stylus speed (0·4 or 0·04 in./min.).

If the bottom is uneven and a careful examination is desired, the fast paper speed will give more separation of the traces. If the echoes are faint, e.g. at greater depths, a slow paper speed will help to accentuate the sounding. If running a line of soundings that require changes of scale, it is advisable to maintain a constant paper speed to assist subsequent analysis.

Before operating the set the paper must be drawn down by turning the milled knob until the stylus can traverse moist paper, otherwise no markings will appear on it.

Electric pencil. An electric pencil is provided for writing on the paper in the same manner as the stylus. If recordings of soundings and times inserted by the pencil are to be kept for any length of time, they must be emphasized in indelible pencil (or ball-point pen), otherwise the record will fade into illegibility.

To operate the set

WARNING: (1) Do not operate the gear change knob unless the recorder is running.

(2) If the phasing is altered when the recorder is stopped, the phasing disc *must be turned clockwise.*

Normal

1. Switch on main d.c. supply.
2. Switch on main a.c. supply.
3. Open front cover of recorder and turn the right-hand knurled knob until moist paper is drawn under the stylus. Close the cover.

4. Sharply rotate the gear-change knob to engage slow speed (if not already engaged).
5. Rotate phasing disc until the figure 0 appears above the centre of the scale.
6. Pull out the paper speed control knob to give slow paper speed.
7. Switch on transmitter.
8. Set the amplifier switch to MANUAL and adjust manual sensitivity control until echo trace can be most clearly seen.
9. Read off depths on appropriate scale.

Shallow water or greater accuracy

1. Sharply rotate gear-change knob to engage high speed.
2. Increase paper speed (if more separation of trace is needed).
3. In less than 30 fathoms set amplifier switch to AUTO and manual sensitivity control to MAX.
4. Read off depths on appropriate scale.
5. If the sounding obtained at slow speed was more than 30 fathoms, but within the limits of the high speed range, rotate the phasing disc clockwise until the echo appears on the trace.
6. Read off the sounding on the appropriate scale and add the phasing value.

Ambiguity in reading deep soundings. When the set is first switched on in deep water a sounding may be obtained from the echo of an earlier transmission and give misleading results. To determine whether the recorded echo is a correct reading or not, the following action should be taken.

Switch off the transmission On-Off switch at the base of the recorder; allow the stylus to complete four rotations; then switch on just before the transmitting contacts operate. Count the number of revolutions completed by the stylus before the echo appears on the trace. If an echo is received immediately after the first transmission, the correct reading is that shown on the recorder. If no echo is received until after the second transmission, the correct reading is the range of the echo sounder plus the depth shown on the recorder. If no echo is received until after the third transmission, the correct reading is twice the range of the recorder plus the depth shown on the recorder.

An alternative method is to count the number of echoes received after the On-Off switch has been switched off. One echo shows that the recorded depth is correct; two echoes show that the range of the echo sounder must be added to the recorded depth; for three echoes add twice the range of the echo sounder. The paper drive must be turned manually to ensure that the stylus traverses well-separated paths on the paper.

EXAMPLE

An echo appears on the trace at 400 + 50 *fathoms. The echo appears after the second transmission (or there are two echoes after the transmission is switched off). The range of the echo sounder is* 1,200 *fathoms.*

The correct sounding is 1,200 + 400 + 50 = 1,650 fathoms.

Reflection echoes. In shallow water an echo may be received from a reflection of the original echo from the ship's hull and from the surface of the sea. These echoes may lead a ship into danger if not recognised; therefore phasing must always start at zero to find the first echo.

CHAPTER 16

Latitude and Longitude, Charts and Hydrographic Publications

LATITUDE AND LONGITUDE

The Earth may be represented, on a small scale, as a globe with the oceans and continents mapped on its surface (fig. 16–1). In order to describe the exact position of any place on this globe it is covered with a network of lines from which the location of a place can be described with reference to the network.

Parallels of latitude; meridians

The lines of this network which encircle the globe and are parallel with the equator are called *parallels of latitude*. Notice that they diminish in circumference the nearer they approach the poles.

The lines which run from pole to pole over the surface of the globe are called *meridians*, the one passing through Greenwich being called the *meridian of Greenwich* (fig. 16–2).

A meridian runs due north and south, and a parallel of latitude runs due east and west; a meridian and a parallel of latitude therefore intersect each other at a right-angle.

Latitude

The latitude of a place is the angular measurement between its parallel of latitude and the equator. The angle is measured at the centre of curvature of the Earth's surface[1] in the plane of the meridian of the place, and is expressed in degrees, minutes and seconds, from 0° to 90° north or south of the equator.

FIG. 16–1. A globe

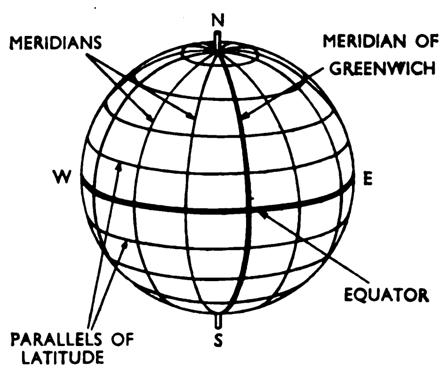


FIG. 16–2. Parallels of latitude and meridians

[1] There is no exact centre of the Earth, because the Earth is not a perfect sphere.

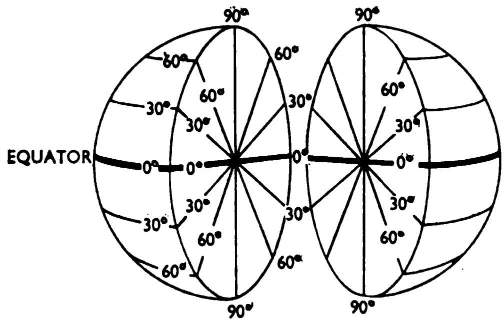


Fig. 16–3. Angular measurement of latitude

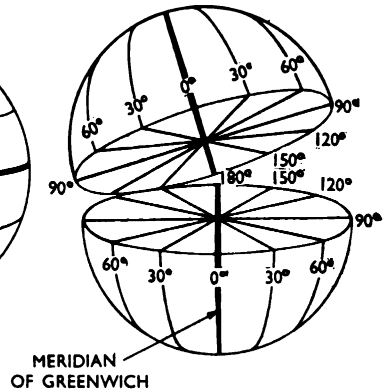


Fig. 16–4. Angular measurement of longitude

Longitude

The longitude of a place is the angular measurement between its meridian and the meridian of Greenwich. The angle is measured at the centre of the globe in the plane of the equator, and is expressed in degrees, minutes and seconds, from 0° to 180°, east or west of the Greenwich meridian.

Position

The position of a place can therefore be described in terms of longitude east or west of the Greenwich meridian, and in terms of latitude north or south of the equator. The Lizard lighthouse, for example, is in latitude 49 degrees, 57 minutes, 36 seconds north of the equator, and in longitude 5 degrees, 12 minutes west of Greenwich. This position is recorded thus:

$$49° 57' 36'' \text{ N.}$$
$$05° 12' 00'' \text{ W.}$$

Linear measurement of latitude

The distance subtended on the surface of a sphere by a degree of latitude is

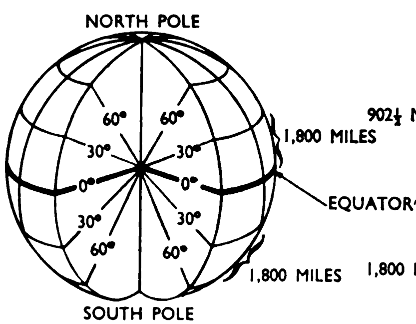


Fig. 16–5. Linear measurement of latitude

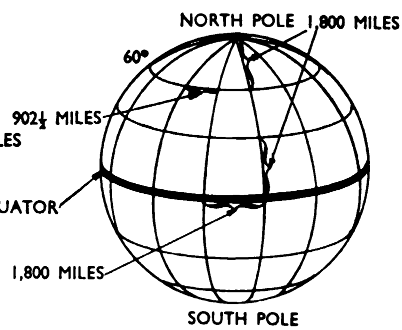


Fig. 16–6. Linear measurement of longitude

exactly the same no matter at what part of the sphere it is measured. For instance, the actual distance between 30 degrees and 60 degrees North will be the same as that between 0 degrees and 30 degrees North.

Because the Earth is not a perfect sphere each minute of latitude subtends a distance which varies from 6,046 ft at the equator to 6,108 ft at the poles. For calibration of distance logs, etc. a convenient mean standard is used; this is the *nautical mile* and its value is exactly 6,080 ft.

Linear measurement of longitude

It will be seen that the distance on the Earth's surface between any two meridians is greatest at the equator and diminishes uniformly until it is nothing at the poles, where all the meridians meet. The linear distance of a degree of longitude on the surface of the Earth therefore varies with its latitude and cannot be taken as a standard measure of length. For instance, the distance on the Earth's surface representing 30 degrees of longitude at latitude 60° N. is about 900 nautical miles, whereas 30 degrees of longitude at the equator is represented by about 1,800 nautical miles.

The great circle

A great circle (fig. 16–7) is any circle whose plane passes through the centre of the Earth, and it is the largest circle one can describe on the Earth's surface. The arc of a great circle is the nearest approach to a straight line which can be drawn on the Earth's surface, and must therefore be the shortest distance between two points. Each meridian is half a great circle, because it joins the poles and its plane passes through the centre of the Earth.

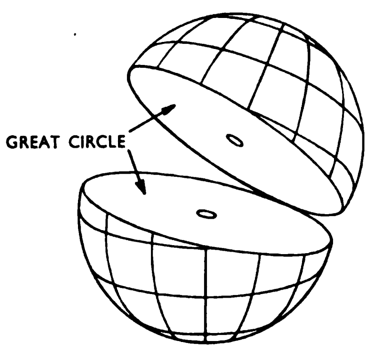


FIG. 16–7. A great circle

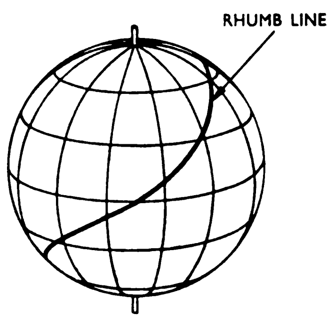


FIG. 16–8. A rhumb line

The rhumb line

Any line which crosses the meridians or the parallels of latitude at the same angle is called a *rhumb line* (fig. 16–8). A rhumb line is not the shortest distance between any two points.

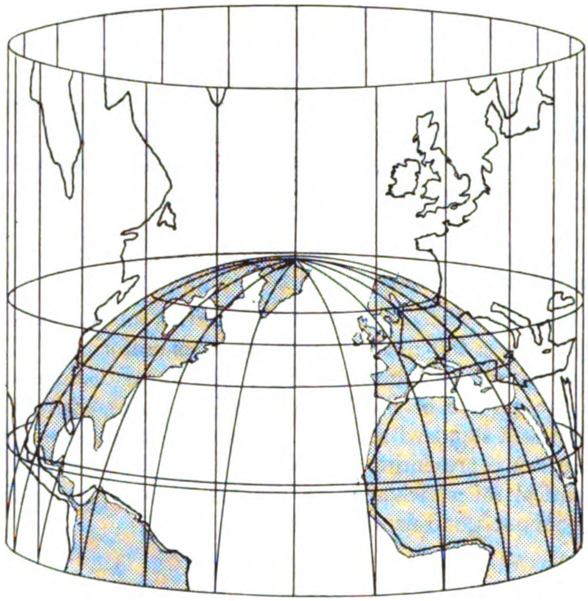


FIG. 16–9. Principle of the central-cylindrical projection

MAPPING

It would be impossible to navigate accurately with the sole aid of a globe, because the drawing of courses and measurement of bearings on a curved surface is difficult and the size of the globe would have to be so large as to render the procedure impracticable. Some means must therefore be found whereby the configuration of continents and oceans can be represented on a flat surface. There are many practical methods of doing this, but each involves a distortion in one way or another of the proportions of the Earth's surface.

Mercator's projection

The method most generally used at sea is Mercator's projection, which is a modified form of the *central-cylindrical projection*, the principles of which are shown in fig. 16–9. Imagine a transparent globe surrounded by a cylinder of paper and with a bright light shining at its centre. The light will throw the shadows of the land, with its continents, islands, etc. on to the inner surface of the cylinder, through which their configuration can be traced. When the cylinder of paper is unrolled the result will be a representation of the Earth on a flat surface, as shown in fig. 16–10. Degrees of longitude are marked along the top and bottom of the map eastward and westward of the meridian of Greenwich, from 0 to 180 degrees. Degrees of latitude are marked along the side of the map northward and southward from 0 degrees at the equator.

Distortions caused by Mercator's method. The distortions and peculiarities of this form of representation of the Earth's surface are explained below and they should always be borne in mind when using a chart (fig. 16–10).

The distance between parallels of latitude increases progressively from the equator towards the poles. This results in a progressive lengthening of all features the farther they are from the equator.

Parallels of latitude, whatever the relative lengths of their circumferences on the Earth's surface, all appear the same length on the chart.

The meridians, instead of meeting at the poles, are represented as straight lines lying parallel with each other and at a constant distance apart. This results in a progressive broadening of all features the farther they are from the equator.

As an example of this distortion, Iceland, lying approximately in latitude 65 degrees north, appears to be about the same size as Borneo, lying on the equator. But Iceland is only 270 miles long and 190 miles broad, whereas Borneo is 620 miles long and 600 miles broad. Fig. 16–11 shows the comparative sizes of the two islands as shown on a Mercator's chart and when drawn to the same scale. Three important points therefore arise:

1. Distance must be measured at its appropriate latitude. The distance between the Isle of Wight and Jersey, for example, must be measured from the latitude scale at the side of the chart opposite the Channel; if this distance was measured from the latitude scale opposite, say, the south coast of France, the result would be entirely erroneous. (Remember that a minute of latitude represents one sea mile.)
2. Any straight line drawn on a Mercator's chart must cut the meridians at the same angle, and is therefore a rhumb line. A ship steering a steady course traverses a rhumb line track (fig. 16–10). (Remember that the rhumb line is not the shortest distance between any two points.)
3. A great circle, which is the shortest distance between any two points, will

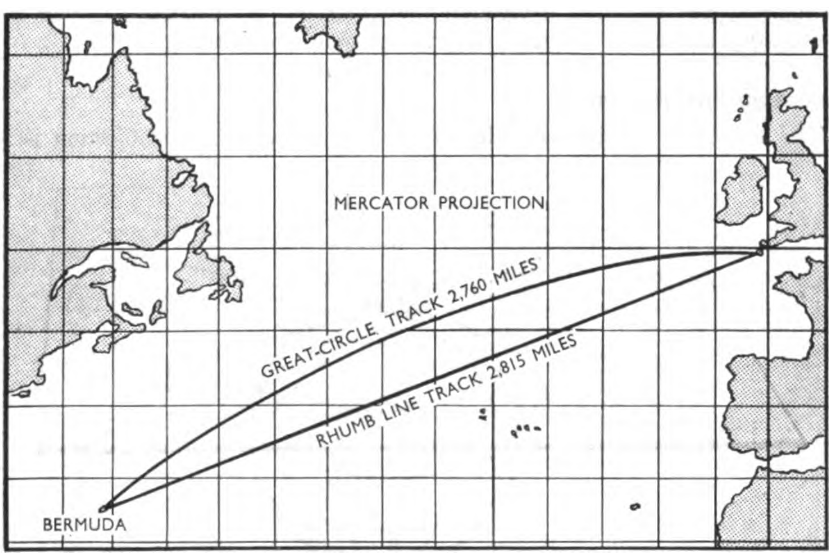


FIG. 16–10. Mercator's projection of the North Atlantic

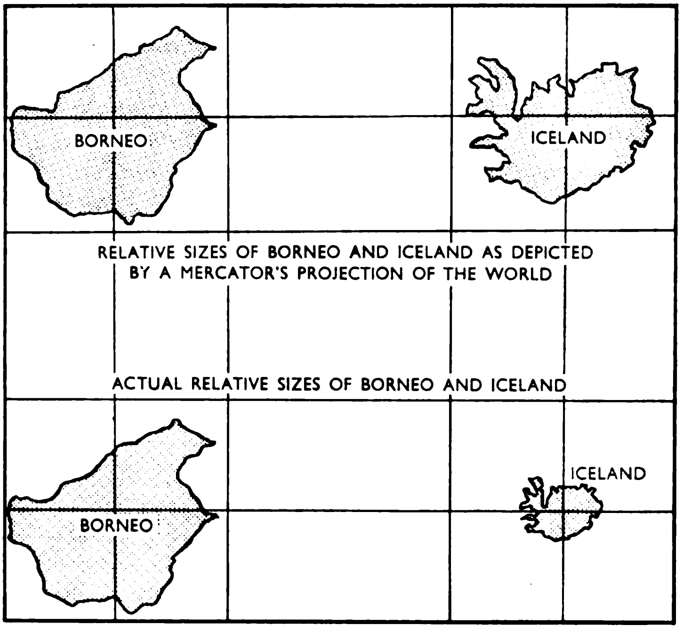


FIG. 16–11. Relative sizes of Iceland and Borneo

appear as a curved line, and will therefore give the false impression that it is longer than the rhumb line joining the same two points (fig. 16–10).

The difference between the plotting of a great circle and a rhumb line on charts can be disregarded in the case of the large-scale charts used for coastal navigation; but in ocean navigation the difference in distance between two places such as Land's End and Bermuda is quite considerable.

Gnomonic projection

The distortion at high latitudes of Mercator's method of projection is so

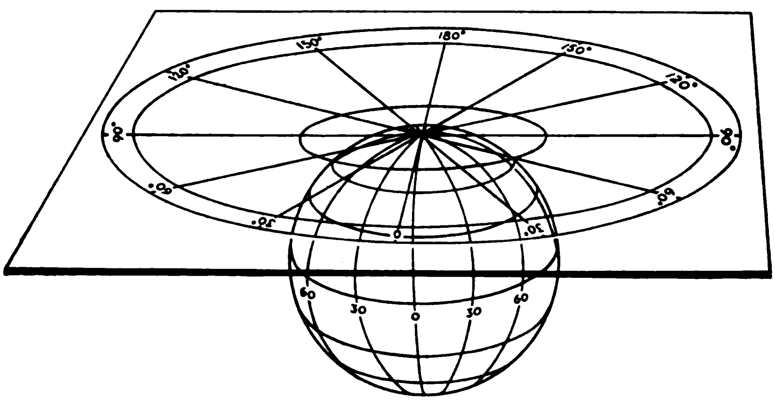


FIG. 16–12. Principle of gnomic projection

great that this method is seldom used to chart the surface of the Earth in latitudes of over 80 degrees north or south. The areas around the poles are usually charted by a method known as the gnomonic projection, the principle of which is described below and illustrated in fig. 16–12.

A sheet of paper is placed with its centre touching either the north or south pole of the globe, and with its plane parallel to the plane of the equator. A light shining at the centre of the globe will project the shadows of the land on to the underside of the paper, through which they can be traced. With the gnomonic projection taken at the poles the parallels of latitude will appear as concentric circles, and the meridians will radiate in straight lines from the pole at their correct relative angles. Great circles will appear as straight lines and rhumb lines as curved lines. Degrees of longitude, from 0 to 180, are marked around the perimeter of the chart each side of the meridian of Greenwich, and degrees of latitude are marked on the concentric circles from the pole outwards, starting at 89 nearest the pole and diminishing as they approach the equator.

Gnomonic projections can be taken at any position on the Earth's surface; those taken at the poles are called *polar charts*, and when taken elsewhere they are called *great-circle charts*. Great-circle charts are useful in determining the shortest track to follow over a long distance between any two places on the Earth. These tracks are transferred to a Mercator's chart for navigational purposes. Fig. 16–13 is a reproduction of a great-circle chart; on it are shown the great-circle and rhumb line tracks between Land's End and Bermuda. In order to follow a great-circle track accurately a ship would have to alter course continuously to follow the curved line; in practice, however, the ship follows a track consisting of a series of rhumb line courses which approximately follow the great-circle track. This track will have to be altered as necessary to avoid land and navigational dangers such as ice and shoals.

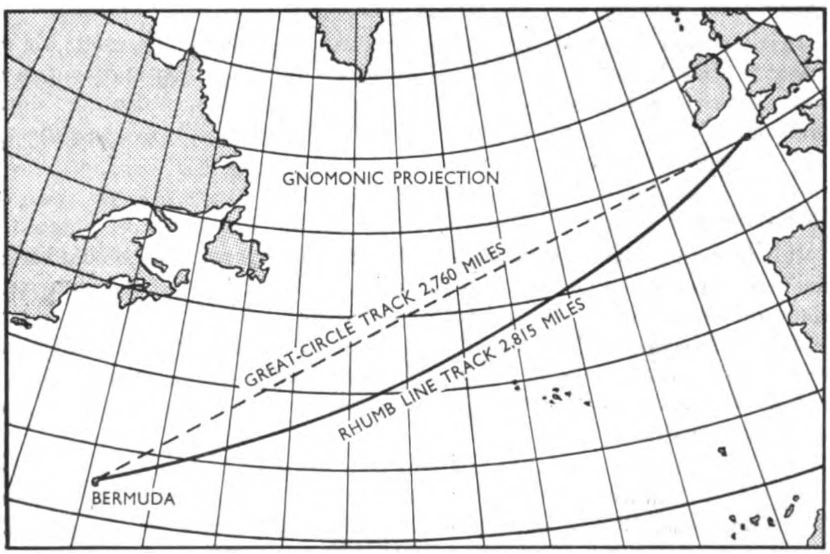


FIG. 16–13. A great-circle chart of the North Atlantic

ADMIRALTY CHARTS AND HYDROGRAPHIC PUBLICATIONS

The Hydrographic Department of the Navy Department, at the head of which is the Hydrographer of the Navy, is a large organisation responsible for the whole production, printing and issue of Admiralty charts and books for H.M. ships and the Merchant Navy throughout the world, and for fishing vessels in home waters. The Hydrographer of the Navy is also the head of the Surveying Branch, which is continuously employed in British waters at home and overseas and in all the oceans of the world. The publication of their work and of that received through an exchange of information with foreign governments ensures that all the navigable waters of the Earth are charted. As new features are discovered, new dangers disclosed, or new demands made for further details the Department keeps all mariners in every part of the world informed of them by *Admiralty Notices to Mariners.*

CHARTS

Types

Charts are issued to cover large or small areas of the seas and coastal regions of the land. A chart which represents a small area is called a *large-scale chart*, and one which covers a large area is called a *small-scale chart*. The terms 'large-scale' and 'small-scale' refer to the ratio between the size of details shown on the chart and their actual size. If, for example, the scale of a chart is shown as 1/12,500, it means that the details on the chart have been reduced 12,500 times; whereas on a small-scale chart on which the scale is shown as 1/1,000,000 the details have been reduced 1,000,000 times. For ocean navigation small-scale charts are used, but when approaching land large-scale charts are used; and finally, when entering port, the largest scale charts called *plans* are used.

In all navigation the largest-scale chart available should be used, for two reasons: first, the larger-scale charts are always corrected first and contain the most details; and secondly, if the paper of the chart has been distorted during printing or by climate and weather, any resultant errors will have less effect on the accuracy of navigation.

Publication

It is most important that charts used for navigational purposes should contain the most detailed and up-to-date information available; they are therefore under constant revision in the Hydrographic Department, which from time to time, and as the necessity arises, issues new charts, new editions of old charts and reprints of existing editions. Notices of all such issues are published in *Admiralty Notices to Mariners*, so that users of charts may obtain the most up-to-date charts available.

The age and state of a chart are indicated along its bottom margin, and by comparing the information there recorded with the latest *Catalogue of Admiralty Charts* and other Hydrographic publications the mariner can ascertain whether it is the most up-to-date chart available. Information regarding the age and state of a chart is recorded on it as follows:

1. The date of publication of a new chart is shown in the middle of the outer bottom margin of the chart, e.g. *Published at the Admiralty, 1st June, 1964.*
2. When a chart is revised throughout or modernised in style, a new edition is published, this fact being recorded to the right of the date of publication, e.g. *New edition, 3rd December, 1964.*
3. When the necessity arises for large corrections to be made to a chart which are too comprehensive for publication in *Admiralty Notices to Mariners*, a reprint is issued embodying such large corrections. This is recorded below the date of edition, e.g. *Large corrections, 15th July, 1964.*
4. Small corrections to charts which are published in *Admiralty Notices to Mariners* are subsequently made by hand, either at the chart depot, or at the chart agency, or by the actual user of the chart. Such small corrections are recorded in the bottom left-hand corner of the chart by inserting the number of the relevant Notice to Mariners against the year of issue, e.g. Small Corrections, 1963—17—224—909, 1964—86—107, etc. They are also embodied and recorded in any subsequent reprints.

Whenever a new chart, a new edition or a reprint is published a notice to this effect is published in *Admiralty Notices to Mariners* and the old copies are cancelled and withdrawn from chart depots, chart agencies and H.M. ships on receipt of the new copies.

Issue

General information relating to the supply of Admiralty charts, navigational publications, maps, chronometers and watches, and the correction of charts and navigational publications, is given in the *Hydrographic Supplies Handbook* (H.51), which is supplied to all ships issued with an Admiralty chart outfit. In the Royal Navy charts are supplied by the Hydrographer of the Navy to Admiralty Chart Depots situated at the Royal Dockyards, from which they are issued to H.M. ships. The general public can purchase Admiralty charts and other hydrographic publications from Admiralty chart agents in the principal ports of the world. A list of these agents is published annually in *Admiralty Notice to Mariners No. 2.* All charts issued by the Hydrographic Supplies Establishment at Taunton, or by chart depots, are corrected to the latest available issue of *Admiralty Notices to Mariners*, but they are not corrected for any temporary and preliminary notices. Chart agents are expected to maintain their stocks up to date.

On first supply of a chart outfit a set of weekly editions of *Admiralty Notices to Mariners*, the latest monthly list of T. & P. (Temporary and Preliminary) notices in force, and any T. & P. notices published since the latest weekly edition, are issued with the outfit.

Indexing and grouping

For convenience of identification each chart is given a reference number, of which numbers there were in 1964 about 4,000. This number is printed at the bottom right and top left corners of the chart, and also on the thumb label which is pasted or printed on the back of the chart.

Navigational charts which cover a certain area (e.g. the English Channel) are grouped together in what is called a 'folio', which is given a number (in this case Folio 1).

The thumb labels provide space for the serial numbers, which are the same for all the charts of the folios, and the consecutive numbers according to the positions of the charts in sequence within the folio.

Complete folios. To cover the globe there are 87 complete folios (1–100 series), and the areas covered by each are shown on a special chart X.6051, 'Limits of Admiralty Chart Folios', which is included at the back of H.51.

Abridged folios. When a ship is on passage she does not necessarily need every chart published for the area through which she will pass. Such a ship is often supplied with complete folios only for the area in which she will eventually operate and with abridged folios (100 series) for the passage. Abridged folio numbers correspond to the complete folio numbers, e.g. folio 105 is the abridged version of folio 5.

Local and special folios (300 series) provide for local services in the vicinity of dockyard ports—for example, a small vessel working out of Portsmouth would be supplied with folio 302, 'North Foreland to Dartmouth'—and folios of such charts as wreck charts and Consol and Loran lattice charts (used with radio fixing aids).

'NOTICES TO MARINERS' AND CORRECTION OF CHARTS

'Notices to Mariners'

The sea-bed and coasts all over the world are constantly changing their form in one way or another, and to ensure safe navigation and pilotage these changes must be notified to the mariner wherever he may be. This is done by means of *Admiralty Notices to Mariners*, published and distributed by the Hydrographer of the Navy. They are sent direct from the Hydrographic Supplies Establishment at Taunton to H.M. ships, chart depots, chart agencies and other distributing centres. They are obtainable from chart depots, chart agencies, Customs Houses and mercantile naval offices in Great Britain, and from the chief shipping offices at home and abroad.

All Notices to Mariners are numbered consecutively from No. 1 upwards throughout the year and are arranged in weekly bound copies also numbered by the week. They contain the latest information on all navigational subjects, include corrections to charts and other hydrographic publications, and are issued in the following forms:

The Weekly Complete Edition, which is printed on white paper and is intended for H.M. ships and merchant ships for general use, contains notices of the publication of new charts, new editions and large corrections of charts, and notices of new navigational publications and new editions of existing navigational publications. It includes corrections to charts and to the *Admiralty List of Lights* and the *Admiralty List of Radio Signals*, and reprints of radio navigational warnings in force. The Weekly Home Edition is a shortened version of the weekly complete edition and contains, broadly speaking,

information relating only to the British Isles and the waters extending to Greenland, Iceland, the White Sea and Gibraltar. It is supplied to H.M. ships, R.F.A.s, merchant ships and authorities whose functions are confined to those areas.

The Quarterly Edition. This is a collection of the weekly editions intended for issue to foreign-going merchant ships.

The Weekly Edition of Fleet Notices. This promulgates classified navigational, meteorological and hydrographic information to ships holding fleet charts. They are printed in violet ink.

Correction of charts

Hand correction of charts should be made in waterproof violet ink, except for preliminary or temporary Notices, which should be made in pencil. The reason for using violet ink is to ensure that any corrections made are distinctive from the original black print of the chart, and can also be seen clearly under the orange artificial lighting common in most charthouses.

Erasures of any sort (except the erasures of pencilled corrections) should never be made on a chart. Any obsolete details should be ruled out in violet ink.

As far as possible any writing should be entered clear of the water area, and details such as cautionary notes and tidal information should be inserted in a convenient but conspicuous space, preferably near the title.

When a correction has been inserted the number of the relevant Notice to Mariners should be inserted against the year at the bottom left-hand corner of the margin.

The recognised symbols and abbreviations (as shown on Chart No. 5011) should always be used. Examples of these are shown in figs. 16–14 to 16–17.

Sometimes, when a great many new details have to be inserted in a small area, the Notices contain a reproduction of a small portion of the chart, with the new information on it, which can be cut out and pasted over the appropriate place on the chart. Two points must here be borne in mind: first, anything written in pencil which you are about to cover up must first be transferred to the *block* (as the new bit is called); and, secondly, the paste must be applied to the chart, not to the block, which it would tend to distort.

If new information is not expected to apply for very long, or if it might have to be altered before being given in its final form, it will be labelled *temporary* or *preliminary* and must be put on the chart in pencil so that it can be rubbed out if necessary. Such Notices are clearly marked (T) or (P), and a list of those still in force is included in the last issue of each month of the Weekly Edition. The text of those still in force is reprinted annually in Weekly Edition No. 1.

HYDROGRAPHIC PUBLICATIONS

There are many publications of value to the mariner, the more important of which are:

The Admiralty Sailing Directions (known as 'Pilots'), which give detailed information of the seas, coasts and harbours of the world, including meteorological information and notes on other phenomena. They are published in

about 75 volumes, divided into the areas covered by the 87 folios of charts. These Pilots amplify the information supplied on a chart and they should be studied in conjunction with their relative charts whenever planning any passage. New editions are published about every 12 years and existing editions are kept up to date by bi-annual supplements, which should always be studied whenever the book is consulted.

The Mariner's Handbook contains information of a general nature on charts and navigational publications issued by the Hydrographic Department, and notes on general navigation, general meteorology and ice.

The Admiralty List of Lights, Fog Signals and Visual Time Signals, which is published in 12 volumes and tabulates the different kinds of navigational lights to be found all over the world; it gives full details about each light and the building on which it stands. The only kind of light not described in the 'Light List' is the light-buoy, for which the largest-scale chart and the appropriate Pilot must always be consulted. The volumes are reprinted at the rate of one every six weeks, i.e. the complete set is reprinted in an eighteen-month cycle.

The Admiralty List of Radio Signals, published in six volumes, describes and tabulates the many forms of radio aids for the mariner, such as time signals, navigational warnings and weather information, Decca, Consol and Loran systems, radio beacons and direction-finding services. These are reprinted yearly.

The Admiralty Tide Tables, which are published annually in three volumes, contain all information necessary to predict the height of tide at most places on the coasts of the world.

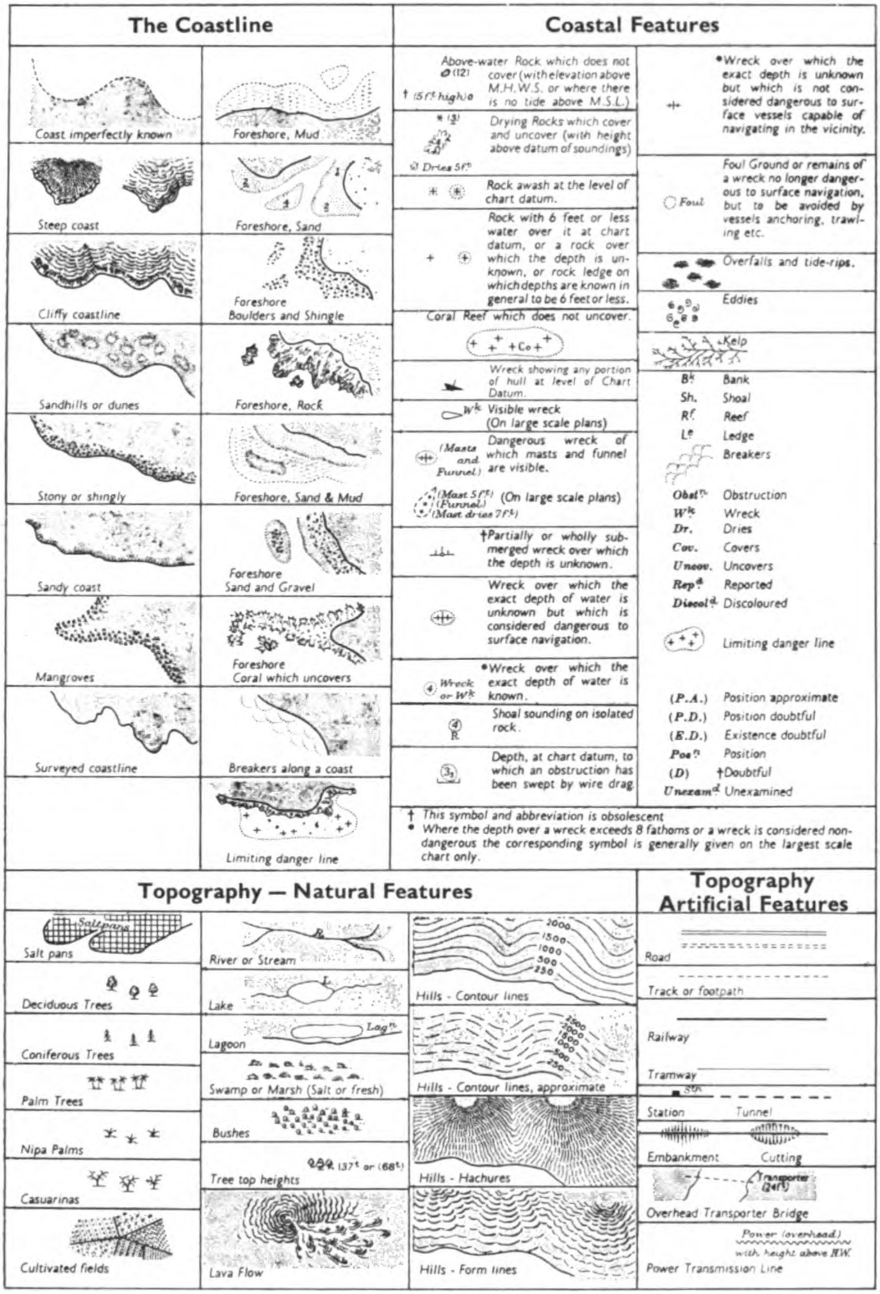


FIG. 16–14. Extracts from Admiralty Chart No. 5011

Lights

★ •	Position of light
L^t	Light
L^t Ho.	Lighthouse
★ B^n	Light beacon
	Light vessel
$L^t V$.	Light vessel
L^{dg}	Leading
Fish^g	Fishing

F.	Fixed
Occ.	Occulting
Fl.	Flashing
Qk. Fl.	Quick Flashing
Int. Qk. Fl.	Interrupted Quick Flashing
Gp. Int. Qk. Fl.	Group Interrupted Quick Flashing
Alt.	Alternating
Gp. Occ. (2)	Group Occulting
Gp. Fl. (3)	Group Flashing
† Fl. (S-L)	Flashing (Short and Long flashes)
† Gp. Fl. (S-L)	Group Flashing (Short and Long flashes)
F. Fl.	Fixed and Flashing
F. Gp. Fl. (4)	Fixed and Group Flashing
Gp. Fl. (B)	Group Flashing —···
Gp. Fl. (PM)	Group Flashing ·——·——
Air Gp. Fl. (AB)	Air light group flashing ·— —···
Fog Det^r. L^t.	Fog Detector Light

Vi.	Violet
Bl.	Blue
G.	Green
Or.	Orange yellow or amber
R.	Red
W.	White
obsc^d	Obscured
(U)	Unwatched
occas^l	Occasional
irreg.	Irregular
Prov^l	Provisional
Temp^y	Temporary
Exting^d	Extinguished
L^r	Lower
vert^l	Vertical
hor^l	Horizontal

Example of abridged description of light. ★ **Gp. Occ. (2) W. R. 5 sec. 130^{ft} 12M. (U).**
All lights are white unless otherwise stated.
Alt (Alternating) signifies a light which alters colour.
The number in brackets after the description of Group Flashing or Group Occulting Lights denotes the number of flashes or eclipses in each group. The characteristics of the Lights which exhibit groups of flashes representing letters of the Morse Code are shown by the appropriate letters in brackets.
Occasional Light (or Fog Signal) is one which is given only when a vessel is expected or in answer to vessels signals or at other irregular times.
The elevation given against a light is the height of the focal plane of the light above Mean High Water Spring Tides, or above Sea Level in cases where there is no tide.
The visibility of lights is given in nautical miles, assuming the eye of the observer to be 15 feet above the sea.
Bearings of lights are given from Seaward.

Buoys and Beacons

• •	Position of buoy or beacon
	Light buoy
• Bell Bell Bell †	Bell buoy
Gong Gong Gong	Gong buoy
Whis Whis Whis	Whistle buoy
BW BW BW Y	Can buoy
BW BW BW Y	Conical buoy
BW	Spherical buoy
	Spar buoy
R RW R BW	**High Focal Plane or Pillar buoy
	Spindle buoy
	Buoys with topmarks
	Barrel buoy
R B	Light float
RY RY	Firing Danger Area buoys
	Wreck buoy
Tel	Telephone or Telegraph buoy
	Mooring buoy
	Mooring buoy with telegraphic & telephonic communications

The position of a Light Vessel, Buoy, or Beacon is the centre of the Base, and is usually indicated by a small circle.
In the case of two-colour buoys each colour is indicated below the appropriate symbol, the colours being shown in alphabetical order.

H.S.	†Horizontal stripes
V.S.	†Vertical stripes
Cheq.	†Chequered
W	White
B	Black
R	Red
Y	Yellow
G	Green
Or	Orange
Gy	Grey
Bl	Blue
	Floating beacons
	‡Fixed beacons
∘ B^n	Beacon, in general
B^n Tower ∘ B^n Tower RW BW	Beacon tower
	Perch
Refl	Reflector

**When exceptionally it is necessary to distinguish the markings more definitely the following variations will be used for horizontal, vertical or chequered buoys —

† This symbol and abbreviation is obsolescent
‡ The abbreviation B^n is normally shown with each fixed beacon symbol
• For Automatic Bell Buoys period and number of strokes shown thus - Bell (2) 90 sec

FIG. 16–15. Extracts from Admiralty Chart No. 5011 (*continued*)

Radio and Radar

o *W/T*	†*Radio Telegraph Station*
o *R/T*	†*Radio Telephone Station*
R°B°	*Radiobeacon*
.W/T B°	†*Radiobeacon*
R°D.F.	*Radio Direction Finding Station*
o *W/TDF*	†*Radio Direction Finding Station*
o *Radio Mast* *Radio T^r*	*Mast or lattice towers of a radio station forming a conspicuous landmark*
R°	*Coast Radio Station which transmits on request ("QTG") for the use of ships D.F.*
Ra.	*Coast Radar Station*
Racon	*Radar Responder Beacon*
	Radar Reflector
Ra Refl.	†*Radar Reflector*
Ra. (conspic)	*Radar Conspicuous Object*
Ramark	*Radar Beacon (continuous)*

† *This symbol is obsolescent*

NOTE:—*Outer circles are in magenta*

Fog Signals

Fog Sig.	†*Fog Signal Station*
Fog W/T	†*Radio Fog Signal*
Explos.	*Explosive Fog Signal*
Sub. Fog Sig.	†*Submarine Fog Signal*
S.B., Sub. Bell	†*Submarine Bell (wave action)*
S.F.B.	†*Submarine Bell (mechanical)*
S.O.	*Submarine Oscillator*
Nauto.	*Nautophone*
Dia.	*Diaphone*
Gun	*Gun*
Siren	*Siren*
E. F. Horn	*Electric Fog Horn*
Bell	*Bell*
Whis.	*Whistle*
Reed	*Reedhorn*
Gong	*Gong*
	Submarine Sound Signal connected to the shore

† *This abbreviation is obsolescent*

Harbours

Prohib^d Anch^e	*Anchorage Prohibited*		*Anchorage*
		Wh^f	*Wharf*
	Fishing Stakes	⑥	*Berth numbers*
Fish Traps	*Fish Traps*	D°	*Dolphin*
L^dg	*Landing place*	• *Bollard*	*Bollard*

Depth Contours

Fathoms	
†	
1	
2	
3	
4	
5	
6	
10	
20	
50	
100	
200	
500	
1000	
2000	
3000	
5000	

NOTE:—*A blue tint is shown on many charts to emphasize the shallow water areas. Normally the tint is inserted between the H.W. line and the 3 fathom line, and a ribbon of tint added on the shoal side of the 6 fathom line, but on some charts other fathom lines may be so tinted. Examination of the chart will reveal the limiting depth of the tint.*

† *This symbol is obsolescent*

Soundings

10 *E.D.*	*Doubtful sounding*
127	*No bottom found*
Dredged to 20 ft (1948)	*Channel or area dredged to depth indicated, at Chart datum (with date of year of dredging)*
3	*Drying height*
7	*Depth, at chart datum, to which an area has been swept by wire drag*
127	*Soundings taken from older surveys or smaller scale charts*
5	*Sounding in fathoms and feet*
4 R	*Shoal sounding on isolated rock*

Buildings

	City, Town
	Village
Cas.	*Castle*
Ho.	*House*
V^a	*Villa*
F^m	*Farm*
+ *Ch.*	*Church*
Cath.	*Cathedral*
R.C.	*Roman Catholic*
	Temple
+ *Ch.*	*Chapel*
	Mosque
	Shinto Shrine
	Moslem Tomb
F^t	*Fort*
• *T^r*	*Tower*
	Windmill
• • *Ch^y*	*Chimney*
• *Water T^r*	*Water Tower*
	Oil Tanks
	Gasometers
Oil Derrick	

FIG. 16–16. Extracts from Admiralty Chart No. 5011 (*continued*)

Tides and Currents

H.W.	High Water	*I.S.L.W.*	Indian Spring Low Water
L.W.	Low Water	*H.W.F.&C.*	†High Water Full and Change
M.T.L.	Mean Tide Level	*L.W.F.&C.*	†Low " " " "
M.S.L.	Mean Sea Level	*Estab^t*	†Establishment
H.W.O.S.	†High Water Ordinary Springs	*Equin^l*	†Equinoctial
L.W.O.S.	†Low " " "	*Q^r*	†Quarter
Sp., Spr.	Spring Tides	†	Current, with rate
Np.	Neap "	5 kn	Flood stream with rate
M.H.W.S.	Mean High Water Springs	5 kn	Ebb " " "
M.H.W.N.	" " " Neaps	*Vel.*	Velocity
M.H.H.W.	" Higher High Water	*Kn.*	Knots
M.L.H.W.	" Lower " "	*H^t*	Height
M.L.W.S.	" Low Water Springs	*H.h.*	Hour
M.L.W.N.	" " " Neaps	*m.*	minutes
M.L.L.W.	" Lower Low Water	*ord.*	†Ordinary
M.H.L.W.	" Higher " "	*Fl. fl.*	†Flood

A B C Positions for which information regarding tidal streams is given on the chart

†Black dots on the Tidal Stream arrows indicate the number of hours after High or Low Water at which the streams are running.

† This symbol and/or abbreviation is obsolescent

Control Points

Δ	Triangulation point
• •	Fixed point
•810	Height of summit
+Obs^{n}Spot	Observation spot
B.M.	Bench mark
• Sea View	View point
Astr^l	Astronomical

Miscellaneous

		Sem.	Semaphore
St^{n}Sta.	Station	*St^{m}Sig.St^n*	Storm Signal Station
C.G.	Coastguard		
		F.S.	Flagstaff
L.B.	Life Boat	*Sig.*	Signal
L.S.S.	†Life Saving Station	*Obs^y*	Observatory
R.S.	†Rocket Station	*Off.*	Office
Sig. St^n	Signal Station		

† This abbreviation is obsolescent

General Remarks

MERIDIANS. Charts are generally drawn on the True Meridian if not, a True Meridian is given on the chart.

LONGITUDES are referred to the Meridian of Greenwich.

CHART DATUM. The reduction level for soundings, where appropriate, is stated either in the Tidal Information Table, or, on older charts, in the title.

SOUNDINGS are generally shown in Fathoms and Feet in depths of less than eleven fathoms, and in Fathoms elsewhere. Some older charts, however, show fractional parts of fathoms in the shoaler areas, and certain large scale charts show soundings in Feet. The unit used is stated in the title of the chart.
The position of the sounding is the centre of the space occupied.

DRYING HEIGHTS. Underlined figures on Rocks and Banks which uncover, express the heights in Feet above the datum of the chart, unless otherwise stated.

HEIGHTS. All heights (except those expressed in underlined figures as above) are, unless otherwise stated, given in feet above Mean High Water Springs, or, in places where there is no tide, above the level of the sea, and are shown thus .125.

Heights are enclosed by brackets in the case of islets, the tops of artificial features (e.g. chimneys) and where the figures are removed from the object.

SCALES The Natural Scale is the proportion which any measurement on the chart bears to the actual distance represented thus $\frac{1}{75,000}$
A Sea Mile is the length of a minute of Latitude at the place, and a Cable is assumed to be a tenth part of a Sea Mile.

DECCA CHARTS. A ‡ shown on certain charts against Adjoining and Larger Scale Chart numbers indicates that a Decca latticed version of that number is published.

DIMENSIONS OF PLATE The figures in brackets in the lower right-hand corner of a chart, thus.- (38·43 x 25·49) are the dimensions of the plate in inches between the innermost graduation or border lines.

DATE OF CHART CORRECTIONS For the method of dating charts for corrections see the introductory chapter in the Admiralty Sailing Directions.

NAMES. Names shown in brackets are generally obsolete names to read with the Admiralty Sailing Directions of an earlier date.
Brackets are also used to denote names which are being changed and occasionally to indicate conventional names

FIG. 16–17. Extracts from Admiralty Chart No. 5011 (*continued*)

CHAPTER 17

Tides and Tidal Streams

TIDES

The periodic rises and falls of the level of the sea constitute what are known as tides. The rise or fall does not occur simultaneously over the surface of an ocean or sea, but appears to radiate outwards from some central area in that ocean or sea, as does the ripple caused by a stone thrown into a pond. The periodic rises and falls of tides are fairly regular, and therefore the height of the tide at any particular time and place can be predicted with a reasonable degree of accuracy.

Causes of tides

The Earth and Moon rotate about a common centre of gravity in a state of equilibrium: in other words, the speed is always exactly sufficient to maintain the Moon in its orbit round the Earth and to counteract the gravitational forces drawing the two masses together.

The gravitational forces act on the Earth as a whole, on the waters on or near the Earth's surface, and on the atmosphere. Since the gravitational force varies with the square of the distance, there will be a greater force acting upon the waters that are closer to the Moon than upon the Earth, and also a greater force acting upon the Earth than upon the waters that are further from the Moon. Therefore there will be a raising of the water immediately under the Moon and a similar 'raising' on the other side of the Earth, where the waters tend to be left behind. A similar, but smaller, tide-raising force is produced by the rotation of the Earth round the Sun.

But for the effects of the shape and depth of the oceans, the position of islands therein and the shape of the land masses, the rise and fall of the tides would closely follow the movement of the Moon round the Earth, varied to some extent in accordance with the positions of the Moon, Earth and Sun in relation to each other. In fact, the manner in which the tides rise and fall in different seas and oceans varies considerably; the period of oscillation of the tide in one area differs from that in another and varies from about 6 to 24 hours. An oscillation of about 24 hours, called a *diurnal* (or daily) tide, would result in one high water and one low water a day; one of about 12 hours, called a *semi-diurnal* (or half-daily) tide, would result in two high waters and two low waters a day; while a 6-hour period would result in four high and four low waters a day. (The term 'tide' includes one complete cycle of one high water and the succeeding low water. It is therefore incorrect to refer to the state of a particular tide as 'high tide' or 'low tide', when what is really meant is ***high water*** or ***low water***. The description 'high tide' would compare the height of that particular tide with that of some previous one.)

The tidal wave

In many cases the tidal wave appears to advance from the centre of an ocean along the surrounding coasts. The advance of the tidal wave around the coasts

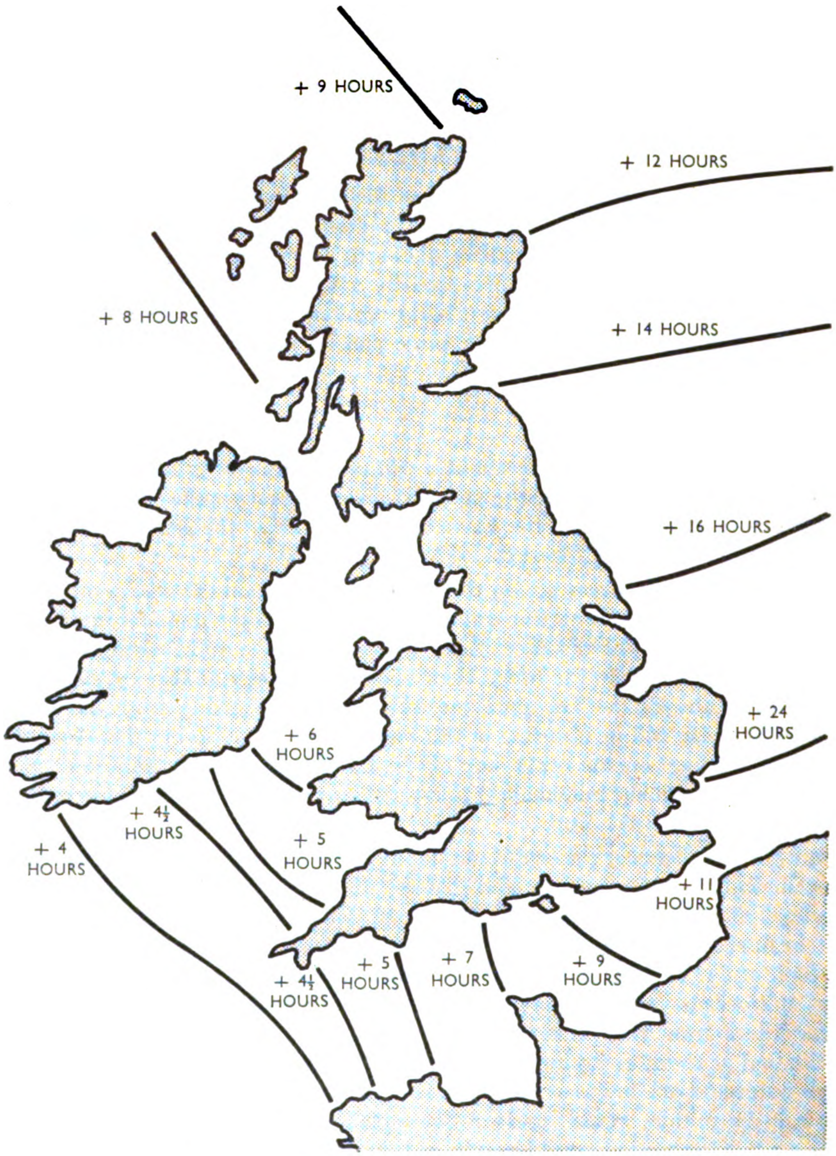


FIG. 17–1. Approximate advance of tide-wave around Great Britain

of Great Britain is illustrated in fig. 17–1; this tide has a period of oscillation of about 12 hours and moves approximately as follows:

at zero + 2 hours it arrives off the coast of Portugal;
at zero + 3 hours it arrives off the western coast of France;
at zero + 4 hours it arrives off Land's End.

At Land's End part of the tidal wave travels up the Channel and reaches the

Straits of Dover at zero + 11 hours, while the remainder continues northward up the west coast of Eire until:

at zero + 9 hours it arrives west of the Orkney Islands, and then passes into the North Sea;

at zero + 12 hours it arrives off Peterhead;

at zero + 24 hours it arrives off Harwich.

Off Harwich this tidal wave meets its successor, which set out from mid-Atlantic at about zero + 12 hours and had travelled up the Channel through the Straits of Dover in the intervening period.

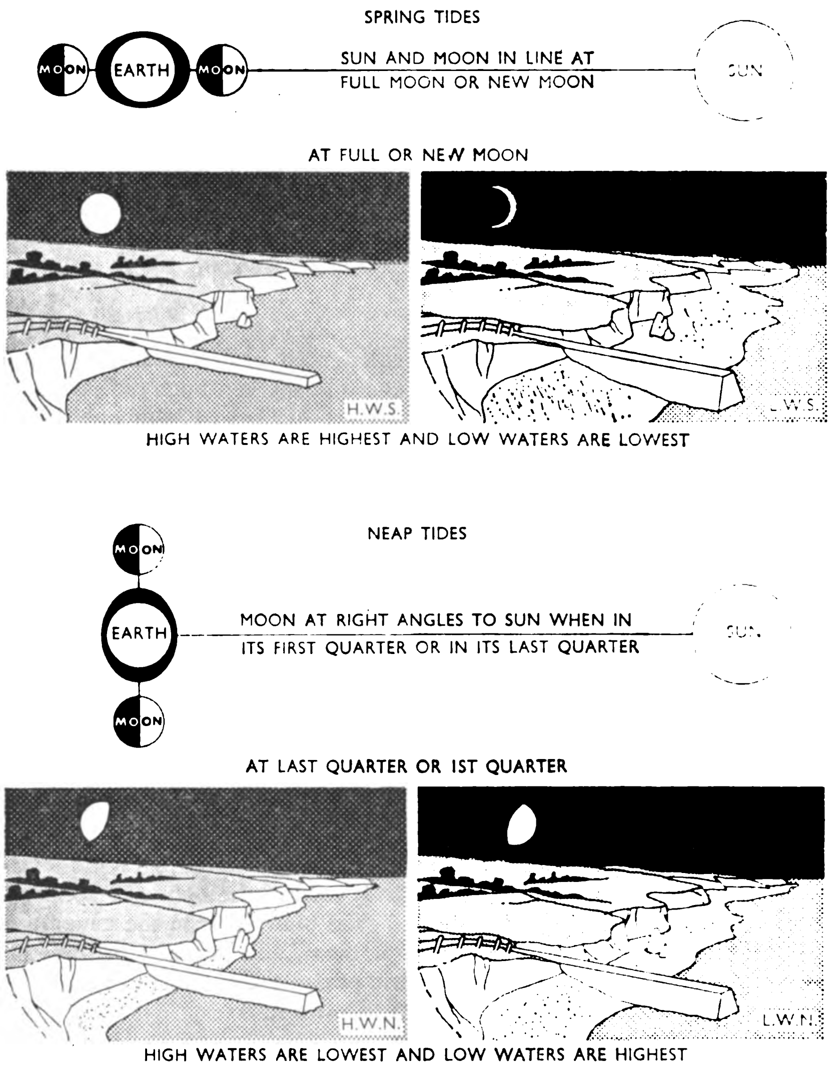


FIG. 17–2. Spring and neap tides

Springs and neaps

The combined tide-raising forces of the Moon and the Sun have their greatest effect when the Sun and Moon are in line with the Earth, i.e. at new moon and full moon, and their least effect when they are approximately at right-angles to each other, i.e. at the first and last quarters of the moon; this is depicted diagrammatically in fig. 17–2. These variations affect the height of the tidal wave and hence the range of the tide, i.e. the difference in level between successive high and low waters. Shortly after full and new moon a locality will experience its highest high waters and lowest low waters of that lunar month, and the tides at this period are called *spring tides*. Conversely, around the times of first and last quarters of the Moon, the lowest high waters and highest low waters of that lunar month will be experienced, at which period the tides are called *neap tides*. Between these limits the heights of successive tides increase or diminish progressively. Spring tides around the British Isles occur at from about one to one and a half days after full or new moon, and neaps occur at about the same interval after the first or last quarters of the Moon. The time interval between successive spring and neap tides is variable, but for practical purposes it can be taken as being about 7½ days (i.e. about one-quarter of an average lunar month of 29½ days). A pictorial representation of the Moon and tide cycle as experienced in the British Isles is shown in fig. 17–3.

Local tides

As previously mentioned, the tides experienced in one locality may differ considerably in period from those experienced in another. Such differences may be apparent at places quite close to each other; for instance, although the tides around the British Isles are semi-diurnal in character, some places may have a double high water (Southampton) and some a double low water (Hook of Holland). In other parts of the world—some parts of the Pacific Ocean, for example—a diurnal tide (i.e. a tide with only one high water and one low water a day) may be experienced, and many localities in the Mediterranean Sea experience little or no appreciable tide. Local knowledge of tides is therefore of great importance to the seaman, and before visiting a strange port he should consult the *Admiralty Tide Tables* to ascertain the behaviour of the tides in that locality. Tidal data, compiled from astronomical calculations and actual observations over a long period, are published yearly in these tables, and from them the actual state of the tide at any major port on any day and at any time can be predicted with a reasonable degree of accuracy.

Effects of weather on tides

The type of local weather experienced may appreciably alter the level of waters in the locality, especially in estuaries such as the Solway Firth, Bristol Channel and Thames Estuary. Prolonged gales blowing from the same quarter will tend to raise the sea level ahead of them, and lower it behind them, especially in shoal waters. Low barometric pressure also tends to raise the sea level, and high barometric pressure tends to lower it.

Interval between tides

The interval of time between one high water and the corresponding high

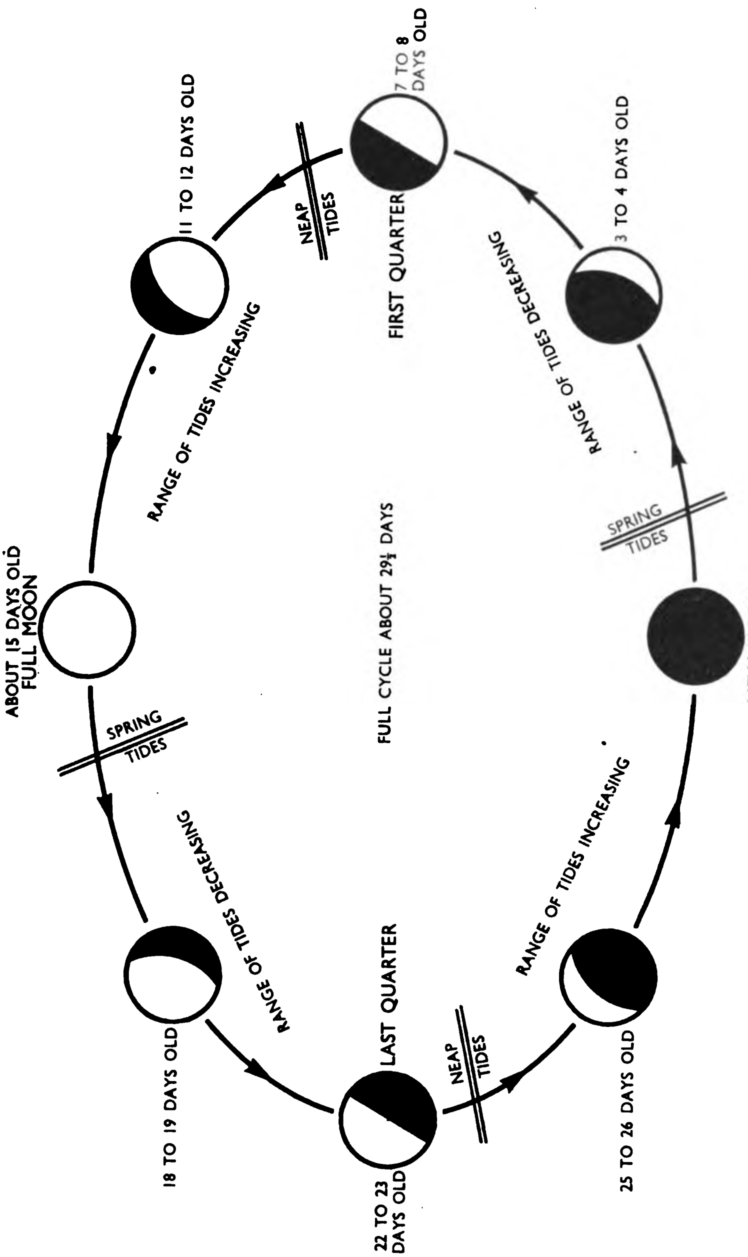


Fig. 17–3. Spring and neap tides in the British Isles relative to the phases of the Moon

water on the following day depends to a large extent on the period of a lunar day, which is about 24 hours 50 minutes. As a rough guide it can be taken that, with a tide whose period of oscillation is regular, high water will occur about 50 minutes later each day.

The interval of time between successive high and low waters will, of course, depend upon the period of oscillation of the parent tide. For a tide with a 12-hour period (such as that experienced around the British Isles) the interval between successive high waters would be about 12 hours 25 minutes, while the interval between one high water and the succeeding low water would be about 6 hours 12 minutes.

Ebb and flood, range and stand

The rising tide is called the *flood tide* and the falling tide is called the *ebb tide*, but care should be taken not to confuse these terms with the *flood stream* and the *ebb stream:* whereas the term 'tide' describes a vertical movement of the sea, the term 'stream' describes the horizontal movement of the sea caused by a tide. The *range* of any tide is the difference between the levels of successive high and low waters, and the *stand* of a tide is the period at high or low water during which no rise or fall can be detected. The occurrence and period of the stand in different parts of the same locality may vary considerably, because they are affected by the formation of the sea-bed and the coast, and by the presence of rivers and streams; local knowledge of these features is therefore of great value.

The rate of rise or fall of a tide will not be uniform, and the extent of the rise or fall every hour will depend on the interval between low and high water. A rough guide to the rise or fall of a 6-hourly tide is given below, but it is emphasised that this method of estimating the approximate height of the tide at any particular time should not be used if *Admiralty Tide Tables* are available, because the results are by no means accurate (see also fig. 17–4). A 6-hour tide may be expected to rise or fall approximately:

1/12 of its range in the first hour
2/12 of its range in the second hour
3/12 of its range in the third hour
3/12 of its range in the fourth hour
2/12 of its range in the fifth hour
1/12 of its range in the sixth hour.

It will be seen that the maximum rate of rise or fall occurs at half-tide, and it follows that connections between ship and shore, such as breast ropes and brows, require particular attention at half-flood and half-ebb. On the other hand, berthing hawsers must be adjusted at high or low water to allow for the range of the tide.

Grounding

The extent of the damage a vessel will suffer through grounding in tidal waters depends upon her construction, the weather and the nature of the

bottom; if still sufficiently watertight, her prospects of floating off again with the return of the tide are as follows:

A vessel grounding on a rising tide will probably soon refloat.

A vessel grounding on a falling tide, say, an hour after high water, will not float again until one hour before the next high water, i.e. about ten hours later in the British Isles.

A vessel grounding at the top of high water, say, two days after springs, should not expect to float without assistance until about two days before the next springs, i.e. about ten days later.

In the above examples it is assumed that meanwhile the ship is not driven further on to the bank or shoal by wind and sea, and that no abnormal tides are experienced.

Tidal definitions

Knowledge of the following tidal definitions is required for chartwork and for use of the Tide Tables. They are illustrated in fig. 17–4, which shows a tide-pole graduated in feet placed where the charted depth is three feet and on a day when the rise of the tide is, say, 19 feet.

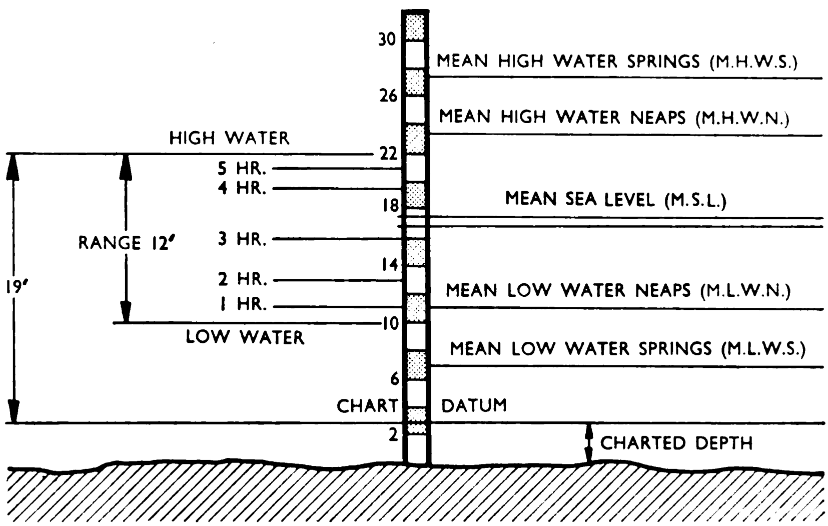


FIG. 17–4. Tidal definitions

Mean Sea Level (M.S.L.). The average level of the surface of the sea.

Tidal Oscillation. A tidal wave represents one vertical oscillation about the mean level of the sea, and, as shown in fig. 17–5, it includes one high water and the succeeding low water.

High Water (H.W.). The highest level reached by the sea during one tidal oscillation.

Low Water (L.W.). The lowest level reached by the sea during one tidal oscillation.

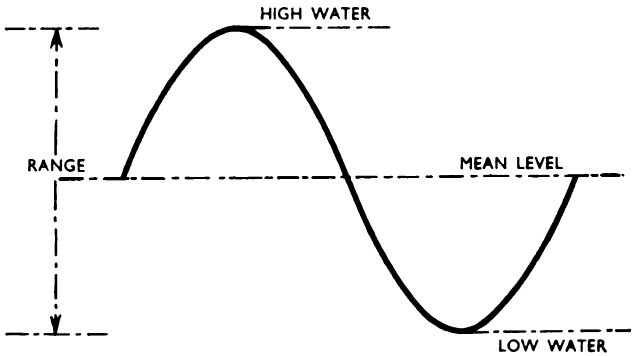


FIG. 17–5. Graph of tidal oscillation

Mean High Water Springs (M.H.W.S.) and *Mean High Water Neaps* (M.H.W.N.). The average heights of high water at springs and neaps, taken over a period of an average year.

Chart Datum. The level below which depths are given on the chart, and above which the height of the tide is measured; the height of the tide at any moment must therefore be added to the charted depth to give the actual depth or sounding. The chart datum is selected during the initial survey of any area, and varies from place to place depending upon the range of the tide in the area. It may be taken as a height below which the tide at that place seldom falls under normal weather conditions.

Tidal information on charts

The depths on a chart show the depths of water *below chart datum;* that is to say, they give the least depths of water to be expected under average circumstances. The chart datum and, where applicable, the mean heights of high and low water above chart datum at springs and neaps, will be found on all except small-scale charts. If the height of mean sea level (M.S.L.) is added to the charted depths the result will give the average depth of water which may be expected at half-tide.

On certain large-scale charts where the tide has a 12-hour period, the rise of the tide (i.e. its height above chart datum) is given for mean springs and neaps, and, if the age of the Moon is known, the height of high or low water on any one day can be roughly estimated from this information; but it is emphasised that this estimation should only be used if the *Admiralty Tide Tables* are not available. In this case springs can be assumed to occur one to two days after new or full moon, and neaps about midway between successive springs; and the rise may be assumed to change regularly between springs and neaps and vice versa.

Thus, to find the approximate height of high water, take one-seventh of the difference between the heights of M.H.W.S. and M.H.W.N., multiply the result by the number of days interval from springs, and subtract this result from the height of M.H.W.S.

To find the approximate height of low water, subtract the height of high water from twice the height of the mean sea level.

EXAMPLE

The heights of high and low water off a port on the south-west coast of England on a certain day are required; the day in question is three days before new moon, i.e. about $4\frac{1}{2}$ *days from springs.*

	feet
Spring rise (from chart)	17·0
Neap rise (from chart)	13·7
Difference	3·3
$4\frac{1}{2} \times 1/7$ of difference	2·1
H.W. height	14·9
$2 \times$ M.S.L. (from chart)	20·2
L.W. height	5·3

Therefore H.W. height is 14·9 ft
and L.W. height is 5·3 ft.

If the time of high or low water is known, the height of the tide for a particular time can be roughly estimated by applying the rough guide for the hourly rate of rise or fall. It is emphasised that this method should not be used if *Admiralty Tide Tables* are available.

EXAMPLE

If the time of high water in the previous example were 0630, *what would be the height of the tide at* 0830*?*

H.W. height	14·9 ft
M.S.L. (from chart)	10·1 ft
Range	$4·8 \times 2 = 9·6$ ft
Interval from H.W.	2 hours
Fall for first hour	$1/12 \times 9·6 = 0·8$ ft
Fall for second hour	$2/12 \times 9·6 = 1·6$ ft
Total fall	2·4 ft
Therefore height of tide at 0830 is	$14·9 - 2·4$
	$= 12·5$ ft

NOTE. Such heights are in practice calculated to the nearest foot.

Admiralty Tide Tables

These are published annually in three volumes, namely:

Volume I —European Waters (including Mediterranean Sea)
Volume II —Atlantic and Indian Oceans
Volume III—Pacific Ocean and Adjacent Seas.

Each volume is divided into two parts, namely:

Part I —Tidal Predictions for Standard Ports
Part II—Tidal Data for Secondary Ports.

Standard ports. A standard port is one for which the times and heights of high and low water have been predicted for every day of the year.

Secondary ports. Each standard port is allocated a number of secondary ports, the tidal features of which are related to those of their parent standard port. The data given in Part II of the Tide Tables include the differences between the times and heights of high and low water at the secondary ports and those at their parent standard port.

Times. All times in Volume I are Greenwich mean time (G.M.T.). (For description of Greenwich mean time, standard time and zone time, see B.R. 45/1, *Admiralty Manual of Navigation*, Vol. I.) The times in Volumes II and III of the Tide Tables are zone times.

The following examples are given to show how the *Admiralty Tide Tables* should be used to find the times and heights of high and low water at standard and secondary ports.

Example 1

What are the standard times and heights of high and low water at Portsmouth on September 7th, 1964?

The index of Volume I of the *Admiralty Tide Tables* for 1964 shows that Portsmouth is a standard port, tidal predictions for which appear in Part I of the volume. Turning to Portsmouth (fig. 17–6), it is seen that on September 7th there are two times of low water but only one of high water, the previous high water having occurred shortly before midnight on September 6th. The times given in the Tide Tables, however, are G.M.T., whereas the standard time kept at Portsmouth at this time of the year is British Summer Time (—1 hour), and one hour must therefore be added to the times given in the Tide Tables. It will therefore be necessary to include the time of the last high water on September 6th.

The standard times of high and low water at Portsmouth on September 7th, 1964, are therefore calculated as follows:

G.M.T. of H.W.	= 2343 Sept. 6th	1211 Sept. 7th
Correction for B.S.T.	= 0100 +	0100 +
S.T. of H.W.	= 0043 Sept. 7th	1311 Sept. 7th
G.M.T. of L.W.	= 0501 Sept. 7th	1721 Sept. 7th
Correction for B.S.T.	= 0100 +	0100 +
S.T. of L.W.	= 0601 Sept. 7th	1821 Sept. 7th

If the heights of low water are minus, this indicates that they are the heights *below chart datum* and should be *subtracted from*, instead of added to, *the charted depths* to give the actual height of low water.

Therefore the standard times and heights of high and low water at Portsmouth on Sept. 7th 1964, are:

H.W. 0043, 13·4 ft; and 1311, 13·8 ft
L.W. 0601, —0·4 ft; and 1821, 0·0 ft.

It follows that on Sept. 7th, 1964, at Portsmouth Harbour in a charted depth

ENGLAND, SOUTH COAST—PORTSMOUTH

Lat. 50°48′ N. Long. 1°07′ W.

TIME ZONE: Greenwich. TIMES AND HEIGHTS OF HIGH AND LOW WATERS

SEPTEMBER						OCTOBER						NOVEMBER					
	TIME	Ht. Ft.		TIME	Ht. Ft.		TIME	Ht. Ft.		TIME	Ht. Ft.		TIME	Ht. Ft.		TIME	Ht. Ft.
1 Tu	0610 1132 1853	10·8 3·9 11·2	16 W	0706 1230 1932	9·7 5·2 10·0	1 Th	0019 0745 1305 2011	3·8 11·2 3·7 11·4	16 F	0013 0734 1255 1949	4·8 10·2 4·7 10·3	1 Su	0215 0922 1442 2141	2·0 13·0 1·8 12·7	16 M	0116 0831 1346 2045	3·0 12·1 2·6 12·0
2 W	0022 0744 1305 2014	3·6 11·0 3·5 11·5	17 Th	0103 0817 1337 2035	4·5 10·2 4·4 10·5	2 F	0141 0855 1413 2113	2·9 12·0 2·7 12·1	17 Sa	0121 0831 1349 2044	3·9 11·0 3·6 11·1	2 M	0258 1005 1521 2223	1·3 13·5 1·1 13·0	17 Tu	0205 0912 1430 2130	2·1 13·0 1·6 12·9
3 Th	0144 0900 1416 2121	2·7 11·8 2·6 12·2	18 F	0203 0915 1429 2127	3·5 11·0 3·3 11·3	3 Sa	0239 0945 1502 2202	1·7 12·9 1·5 12·7	18 Su	0206 0914 1430 2125	2·8 12·0 2·5 12·0	3 Tu	0336 1043 1556 2300	0·8 13·7 0·7 13·3	18 W	0250 0956 1515 2216	1·3 13·7 0·8 13·6
4 F	0245 0958 1511 2212	1·6 12·5 1·5 12·8	19 Sa	0248 0957 1507 2205	2·4 11·7 2·3 12·1	4 Su	0322 1028 1544 2244	0·7 13·5 0·8 13·2	19 M	0246 0953 1508 2206	1·8 12·9 1·5 12·9	4 W	0411 1118 1630 2337	0·6 13·8 0·5 13·3	19 Th	0336 1039 1559 2305	0·7 14·3 0·2 14·1
5 Sa	0335 1046 1600 2259	0·6 13·2 0·7 13·1	20 Su	0324 1033 1544 2242	1·4 12·6 1·5 12·8	5 M	0401 1109 1621 2322	0·1 13·9 0·4 13·4	20 Tu	0325 1031 1546 2245	0·9 13·7 0·8 13·6	5 Th	0446 1152 1703	0·7 13·7 0·6	20 F	0421 1124 1644 2353	0·2 14·5 -0·2 14·2
6 Su	0420 1132 1640 2343	-0·1 13·6 0·2 13·4	21 M	0358 1108 1620 2318	0·8 13·3 0·9 13·4	6 Tu	0437 1146 1657 2359	-0·1 13·9 0·2 13·5	21 W	0405 1110 1627 2326	0·3 14·3 0·2 14·1	6 F	0011 0519 1224 1735	13·2 1·0 13·4 0·8	21 Sa	0506 1211 1728	0·0 14·3 -0·3
7 M	0501 1211 1721	-0·4 13·8 0·0	22 Tu	0435 1143 1656 2352	0·3 13·8 0·5 13·8	7 W	0513 1220 1732	0·0 13·8 0·3	22 Th	0446 1149 1707	-0·1 14·5 -0·1	7 Sa	0045 0552 1256 1805	13·1 1·5 13·1 1·2	22 Su	0038 0553 1300 1814	14·0 0·2 14·0 -0·1

FIG. 17–6. Excerpt from *Admiralty Tide Tables*, Volume I, Part I

of 3 fathoms (18 ft) there is a depth of 31·4 ft at 0043, and a depth of 17·6 ft at 0601.

EXAMPLE 2

What are the local times and heights of the afternoon high and low waters at Barfleur on 6th February, 1963?

Barfleur is on the north coast of France, and it will be seen that in the index of Volume I of the *Admiralty Tide Tables* there is against Barfleur a number (1599) which shows that it is a secondary port. On looking up Barfleur in Part II, it will be seen that Cherbourg is the standard port. On looking up Cherbourg in Part I, it will be seen that the times and heights of high and low water for p.m. on 6th February, are:

H.W. 1846, 18·5 ft
L.W. 1304, 5·6 ft.

	Standard Port	Lat. N.	Long. W.	High Water at		Low Water at		High Water		Low Water	
1600	**CHERBOURG** .. .. .. (see page 153)	49 39	1 38	0900 and 2100	0300 and 1500	0300 and 1500	0900 and 2100	F. 20·7	F. 16·1	F. 3·0	F. 7·6
	Secondary Ports			Time Differences				Height Differences			
	France, North Coast—*cont.*	N.	W.	H. M.	H. M.	H. M.	H. M.	F.	F.	F.	F.
1598	St Vaast-la-Hougue	49 34	1 16	+0 46	+0 51	+1 11	+1 07	+1·6	+1·0	[illegible]	+0·1
1599	Barfleur	49 40	1 15	+0 44	+0 51	+0 41	+0 41	+0·3	+0·9	+0·3	0
1601	Omonville	49 43	1 52	−0 22	−0 27	−0 35	−0 33	−0·4	+0·1	+0·1	0
1602	Goury	49 43	1 56	−0 51	−1 07	−1 19	−1 25	+5·1	+4·9	−0·4	+2·1

FIG. 17–7. Excerpt from *Admiralty Tide Tables*, Volume I, Part II

On turning back to Barfleur in Part II (fig. 17–7) it will be seen that the time differences are related to specific times of high and low water at Cherbourg; also that the height differences are related to specific heights of high and low water. Interpolation may be necessary between the respective times and heights shown if they differ appreciably from the actual times and heights on the day in question, or if great accuracy is required. In this example the variation in time for high water amounts only to 7 minutes over a 6-hour period; and the variation in height for high water amounts to only 0·6 ft over a range of 4·6 ft, and for low water it is only 0·3 ft over a range of 4·6 ft.

The time 1846 lies at a little over half the interval between 1500 and 2100, so the time difference for H.W. should read + 0 h 47 m.

The height 18·5 ft lies at about one-half of the way between 16·1 and 20·7 ft, so the height difference for H.W. should read + 0·6 ft.

The height 5·6 ft lies at a little more than half-way between 3·0 and 7·6 ft, so the height difference for L.W. should read + 0·1 ft.

The times and heights of high and low water at Barfleur are therefore obtained by applying these differences to the times and heights at Cherbourg, as shown below:

Cherbourg H.W.	.. ..	1846	18·5 ft
Differences	.. ..	+47	+0·6
Barfleur H.W. ..	.. ..	1933	19·1 ft
Cherbourg L.W.	.. ..	1304	5·6 ft
Differences	.. ..	+41	+0·1
Barfleur L.W. ..	.. ..	1345	5·7 ft

France keeps G.M.T. in the winter months, and so no time corrections are necessary. Therefore local times and heights of high and low water at Barfleur on the afternoon of 6th February are:

L.W. ..	..	1345, 5·7 ft
H.W. ..	..	1933, 19·1 ft

TIDAL STREAMS

Description, definitions and behaviour

Although the tidal wave does not carry the water along with it, its passage along a coast does produce periodic horizontal movements of water, called *tidal streams*, which flow in and out of harbours and along the coast. They are related to the rise and fall of the local tide and are influenced by past and existing weather. It must not be imagined, however, that a piece of wood floating in mid-Atlantic will reach Portugal in two hours, and Land's End two hours later, in accordance with the progress of the tidal wave; but a baulk of timber carried out of harbour on the outgoing stream might reasonably be expected to return again on the ingoing stream, except where a strong river stream meets tidal water in the harbour, or where other currents outside carry the timber away or wash it ashore meanwhile.

A rising tide in harbour is accompanied by what is often called the 'flood' stream, and a falling tide by what is often called the 'ebb' stream. As, however, neither the flood nor the ebb streams necessarily change their direction at the times of high and low water, they should, when in harbours and rivers, be called respectively the 'ingoing' and 'outgoing' streams, but when offshore they should be named in accordance with the direction in which they are flowing, e.g. 'north-going stream', 'east-going stream'.

In the course of time these streams may carve out channels in the sea-bed and throw up banks and shoals between them. The water in such channels is known as the *tideway*, and may be expected to flow seaward for about six hours, then slacken, then turn and flow for six hours in the reverse direction until it becomes slack water again, and so on. The period of slack water will not necessarily coincide exactly with the times of high and low water.

The tidal stream along a stretch of coast will usually flow parallel with the coastline, but where such a stream meets river streams it may be deflected in any direction.

Unlike a wind, a tidal stream is named by the direction in which it is *going*, so we speak of a 'west-going stream', or a 'stream setting 270°', for example.

Clear indication of the set or direction of the stream is given by ships riding head-on to it, or by buoys canting away from it (except the spar buoy, which is

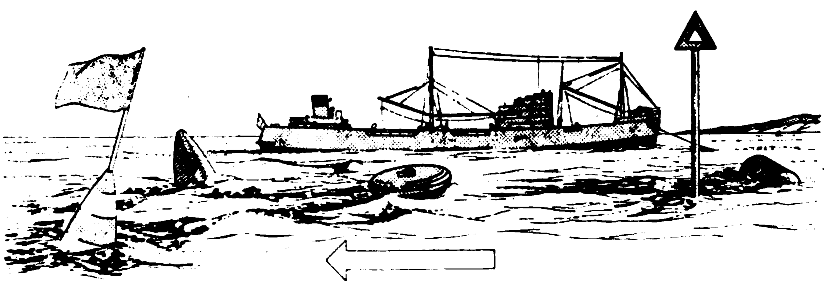


FIG. 17–8. Indications of the direction in which a tidal stream is setting

moored so that its staff inclines up-stream or down-wind, whichever is the stronger), or by the ripple of water in the wake of a moored object such as a buoy (fig. 17–8). Inshore, indications are given by drifting flotsam and by the ripple in the wake of posts or piles. By noting such indications the seaman saves himself much time and labour in boatwork, and avoids possible damage to his craft when going alongside.

The tidal stream runs faster where the water is deeper or the channel narrower. At the mouth of a river or in the waters of an estuary the stream usually runs most strongly during the third and fourth hours of any tide, and these half-tide streams reach their maximum rate at the period of springs.

Extra care should be taken when proceeding along coasts where the tidal range is considerable, especially when passing bays where there are generally indraughts although the general run of the tidal stream may be parallel with the shore. The turn of the tidal stream off-shore seldom coincides with the times of high and low water inshore, and the difference off deep indentations in the coast may amount to as much as three hours. Along straight stretches of coast the tidal stream off-shore will turn shortly after high and low water.

Harbour tidal streams. When a river current meets tidal water the outgoing stream will naturally run longer and stronger than the ingoing stream, especially if the river is swollen after recent rains; such an exceptionally strong outgoing stream is called a *freshet.* When backed by a river current the outgoing stream can run very strongly indeed at half-ebb, particularly at the period of spring tides.

Weather-going stream. Whenever a strong stream is flowing against the wind an uncomfortably short, steep sea is raised; this sea usually abates noticeably at the turn of the tide. Such conditions call for extra care in handling boats and in tending boats secured alongside a ship in the tideway.

Tidal rivers. In tidal rivers the flow or stream is usually stronger in mid-stream on straight stretches, but on bends the flow and channel usually hug the outer shore of the bend. Promontories, groynes, piers, and all similar projections of the banks into a river usually cause shoals to form on either side of them, unless the bank is steep, the river bed rocky or the river sluggish. *The terms right and left bank of a river assume the observer to be facing its mouth from a position up-river.*

River eddies. At certain stages of the tide it may be found that part of the stream is deflected by some point of land in such a way that it forms eddies close inshore. For a time the eddies may combine to form a stream flowing in the opposite direction to that of the main stream. Use can often be made of these contrary eddies to assist a boat in making headway against the main stream.

Turbulence. Turbulence may be defined as the disturbance of the even flow of a current or tidal stream. It may be caused by an obstruction such as a promontory, island, pier or jetty; or by the meeting of opposing currents or streams, or by a sudden change in the depth of water such as occurs with the formation of potholes in the sea-bed. Under the heading of 'turbulence' can be classed such disturbances known as eddies, ripples, overfalls and races.

Turbulence of one sort or another usually occurs on the lee side of an obstruction (i.e. the side opposite to that against which the stream or current

flows), and may take the form of steep, confused seas which may constitute a danger to boats or small vessels. Turbulences are often marked on charts, and it is wisest for small vessels to give them as wide a berth as possible.

Sources of information on tidal streams and currents

Information on tidal streams can be found in the appropriate *Atlas of Tides and Tidal Streams*, when one is published for the area in question, and in the appropriate volume of the *Admiralty Sailing Directions*.

Currents are the movements of water in the oceans caused mainly by the prevailing winds. Information on currents is given in the *Current Atlas of the World*, and also in the appropriate *Admiralty Sailing Directions*.

Information on both tidal streams and currents is also given on most charts, as explained below.

Indication of tidal streams and currents on Admiralty charts

The existence of a current is indicated on Admiralty charts, thus ⋙⟶.

The existence of tidal streams is usually indicated on the large-scale Admiralty charts of coasts and harbours by diamonds enclosing letters or figures, e.g. ⟨B⟩, which refer to tables of tidal streams given on some convenient portion of the chart. These tables indicate the direction and rate of the tidal streams and the periods of slack water, in the vicinity of the diamonds, relative to the periods of springs and neaps and the times of high and low water at the local standard port.

On some older charts different forms of arrow are used for this purpose, as follows:

\\\\———→ indicating a flood stream;

————→ indicating an ebb stream;

\\\\—•-•-•→ (dots on a flood stream arrow), the number of dots indicating the interval in hours after low water;

——•-•-•→ (dots on an ebb stream arrow), the number of dots indicating the interval in hours after high water.

Sometimes times and rates are indicated on the arrows; thus $\overset{2\frac{1}{2}}{\text{\\\\—•-•-•→}}$ indicates that the rate is 2½ knots 3 hours after local low water; there are no means of adjusting the rate given according to the range on the day, unless it is stated to be spring, neap or mean rate.

How to forecast a tidal stream from information on a chart

EXAMPLE

What is the direction and rate of the tidal stream in the Shipway Channel off Harwich at 0900 B.S.T. on 4th August, 1963?

On Admiralty chart No. 2052, 'England—East Coast: The Naze to Orfordness', in the vicinity of the Shipway is a diamond enclosing the letter

52°

Tidal Streams referred to H.W. at HARWICH

Hours	A 51°50'·1N. 1°29'·4E. AA6			B 51°58'·1N. 1°34'·1E. AA5			C 51°59'·6N. 1°29'·4E. AA4			D 52°04'·9N. 1°36'·4E. AA1			E 51°56'·4N. 1°23'·6E. AA2		
	Dirⁿ	Rate (kn) Sp.	Np.	Dirⁿ	Rate (kn) Sp.	Np.	Dirⁿ	Rate (kn) Sp.	Np.	Dirⁿ	Rate (kn) Sp.	Np.	Dirⁿ	Rate (kn) Sp.	Np.
Before H.W. Harwich 6	133°	0·2	0·1	215°	0·4	0·3	208°	0·6	0·4	211°	0·8	0·5	229°	0·4	0·3
5	212°	1·3	0·8	210°	1·4	0·9	213°	1·4	0·9	217°	2·0	1·3	225°	1·1	0·7
4	[illegible]	[illegible]	1·3	[illegible]	[illegible]	[illegible]	214°	1·7	1·1	215°	2·5	1·7	226°	1·3	0·8
3	215°	2·1	1·4	214°	1·8	1·2	214°	1·6	1·0	214°	2·5	1·7	227°	1·2	0·8
2	219°	1·7	1·1	[illegible]	[illegible]	[illegible]	217°	1·3	0·8	212°	2·2	1·3	233°	0·9	0·6
1	230°	1·1	0·7	223°	0·9	0·6	225°	0·6	0·4	207°	1·2	0·6	256°	0·6	0·4
H.W.	273°	0·4	0·3	018°	0·2	0·1	026°	0·5	0·3	053°	0·3	0·2	020°	0·3	0·2
After H.W. Harwich 1	026°	0·9	0·6	033°	1·1	0·7	034°	1·6	1·0	029°	2·0	1·3	049°	1·1	0·7
2	035°	1·8	1·2	036°	2·2	1·5	034°	1·9	1·2	031°	2·9	1·9	052°	1·4	1·0
3	038°	2·1	1·4	035°	1·9	1·3	033°	1·6	1·0	033°	2·8	1·8	054°	1·2	0·8
4	041°	2·0	1·3	036°	1·4	0·9	035°	1·2	0·7	033°	2·2	1·6	053°	0·9	0·6
5	043°	1·2	0·8	036°	0·8	0·5	041°	0·6	0·4	036°	1·2	0·8	052°	0·5	0·3
6	061°	0·4	0·2	Slack			045°	0·1	0·0	033°	0·2	0·1	252°	0·1	0·1
	F 51°52'·4N. 1°20'·5E. A02			G 51°52'·1N. 1°36'·9E. A03			H 52°01'·5N. 1°47'·5E. A01			I 51°53'·6N. 1°28'·9E. A52			J 52°02'·0N. 1°42'·1E. A50		

FIG. 17–9. Table of tidal streams from Chart No. 2052

B; this refers to position B in the table of tidal streams on the left-hand side of the chart (reproduced in fig. 17–9).

These tables show the standard port (in this case Harwich), and the direction and rate of the tidal stream at springs and neaps for six hours before and after high water at Harwich.

Now, 0900 B.S.T. = 0800 G.M.T., and from the *Admiralty Tide Tables, Vol. I*, Part I, we find that:

H.W. at Harwich on 4th Aug. = 1057 G.M.T.

therefore the interval required = 3 hours before H.W.

Entering the table under position B on the chart with this interval, it is found that:

the direction of the stream = 214°

the rate of the stream = 1·8 knots for springs, and 1·2 knots for neaps.

To calculate the rate of the stream for that hour the range of that particular tide must be divided by the spring or the neap range, and the result must be multiplied by the spring or neap rate shown against the hourly interval from high water. From an examination of the heights of the tides at Harwich during August, it is seen that springs occur about August 8th and neaps about July 31st. August 4th is nearer springs than neaps, so the data for springs must be taken.

Tidal Information and Chart Datum

Place	Height above datum of soundings				Datum to which soundings are reduced and Remarks
	High Water		Low Water		
	Mean Springs	Mean Neaps	Mean Springs	Mean Neaps	
Orfordness	9·0 feet	8·3 feet	0·9 feet	2·3 feet	5·43 fᵗ below Ord. Datum (Newlyn).
Orford Haven Bar	7·8 "	6·6 "			
Bawdsey	11·0 "	9·6 "	1·4 "	2·8 "	6·10 fᵗ below Ord. Datum (Newlyn).
Woodbridge Haven	10·0 "	[illegible]	[illegible]	1·9 "	6·33 fᵗ below Ord. Datum (Newlyn).
Harwich	12·6 "	10·5 "	1·1 "	2·9 "	6·58 fᵗ below Ord. Datum (Newlyn).
Walton on the Naze	[illegible]	10·2 "	[illegible]	2·0 "	5·86 fᵗ below Ord. Datum (Newlyn).

FIG. 17–10. Tidal information from Chart No. 2052

Just above the table of tidal streams on the chart is a table of Tidal Information and Chart Datum (reproduced in fig. 17–10), giving the mean heights of springs and neaps at various places, including Harwich.

From the *Admiralty Tide Tables*, we find that:

the height of H.W. at Harwich at 1100 on August 4th = 12·0 ft
the height of the preceding L.W. = 2·1 ft
therefore the range of tide = 9·9 ft.

From the table of tidal information on the chart we find that:

the rise of M.H.W.S. at Harwich = 12·6 ft
the rise of M.L.W.S. at Harwich = 1·1 ft
therefore the spring range = 11·5 ft.

From the table of tidal streams on the chart we find, under position B, that:
the spring rate at three hours before H.W. = 1·8 knots

$$\text{therefore the rate required} = \frac{9{\cdot}9}{11{\cdot}5} \times 1{\cdot}8 = 1{\cdot}5 \text{ knots.}$$

The answer is, therefore, that the direction and rate of the tidal stream in the vicinity of the Shipway at 0900 B.S.T. on August 4th is 214°, 1·5 knots.

A more general picture of the streams in this vicinity is given in the *Pocket Tidal Stream Atlas of the Thames Estuary*.

CHAPTER 18

Introduction to Pilotage

At sea there are neither roads nor signposts, but there is an almost unlimited number of ways of getting from one place to another, and the choice must be made after careful study of the charts, taking into account such factors as the draught of the ship, rocks, shoals, weather and other shipping. Having selected the intended track and marked it in pencil, it is then most important to ensure that the ship stays on it, otherwise she may so easily and quickly run into danger.

Navigation is the art of taking a ship safely from one place to another. If the ship is out of sight of land she can find her position by sextant observation of the Sun, Moon and stars; or by radio navigational aids such as Consol, Loran, Decca and Direction Finding when within the coverage of these systems. If the ship is within sight of land she can establish her position by taking bearings of recognised features on the land or seamarks; or she may fix by radar; and she can check her position by soundings.

Pilotage is that part of navigation which concerns the safe conduct of a ship in the vicinity of coasts, in narrow waters, and in the vicinity of dangers such as rocks and shoals. Broadly speaking, navigation in pilotage waters may be considered as coming under two headings:

Coastal navigation, which concerns that part of a sea passage in which the navigator has the land on one side of his course and the open sea on the other;

Channel navigation, which is required when a ship has to be navigated in narrow channels with dangers on both sides, and in rivers or harbours and their approaches, as usually occurs at the start and finish of a sea voyage.

This chapter is intended to introduce the seaman to the art of pilotage, and to describe the simple and more usual methods by which a ship's position, course and speed are estimated and checked when she is in pilotage waters.

CHARTWORK

Preparing a chart for passage

Whether a ship is making a voyage of many hundreds of miles or a small craft is crossing a few miles of coastal waters, the planned track must be pencilled on a chart. Let us consider the problem of taking a small vessel from Portland to Plymouth. The general small-scale chart of the area is extracted from the folio, and the planned track is marked in pencil. This track consists of a number of straight lines joining selected points of the route, making quite certain that they lead clear of any dangers. The courses are then written against these straight lines, both the true courses and the magnetic courses. The distances from the destination can then be marked at intervals along the route so that the progress of the ship can be checked from time to time.

All the large-scale charts for the passage are now extracted from the folio and prepared in a similar way. It is these charts that must be used, because the largest-scaled chart always has more detail on it.

Describing and plotting a position at sea

When it is necessary to describe a position at sea to establish a new danger or the rendezvous between ships, or for a ship to report her own position, it can be done by giving the latitude and the longitude, or the bearing and distance from a prominent landmark.

Plotting latitude and longitude. Place one edge of the parallel ruler along a parallel of latitude and move the ruler until one edge passes through the latitude

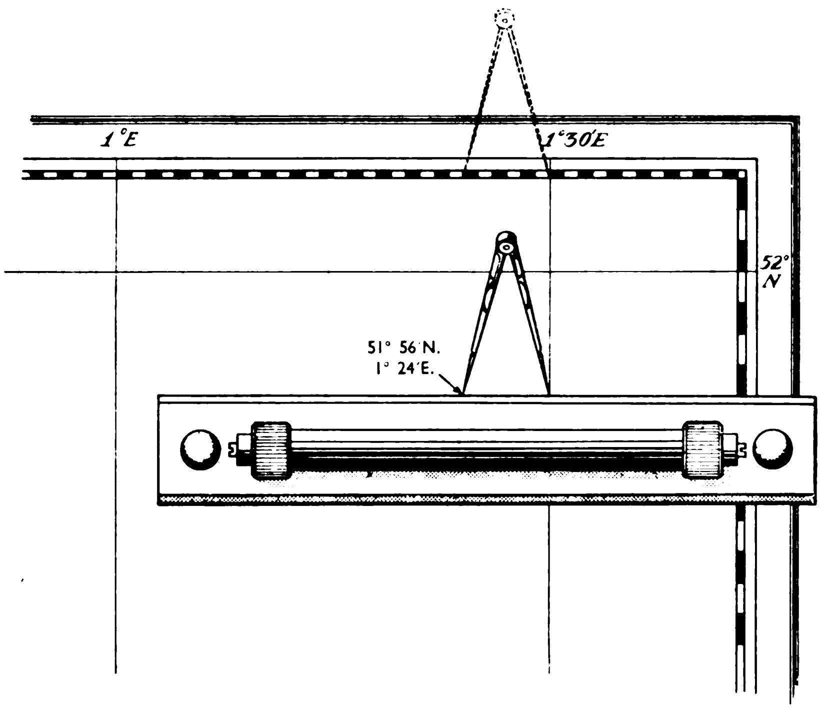


FIG. 18–1. Plotting a position by latitude and longitude

of the place as indicated at the side of the chart. With the dividers, measure the distance at the top or bottom of the chart from the nearest meridian to the required longitude, and lay this off from the same meridian along the parallel of latitude shown by the ruler (fig. 18–1). If more convenient, the ruler can be placed to the longitude and the latitude then be set off with the dividers.

Alternatively, the latitude and the longitude may be drawn in by pencil, using the parallel ruler only.

Plotting bearing and distance. A position may be described by its bearing and distance from a known position such as a landmark or lighthouse; for example, '135 Eddystone 5' means that the position lies in a direction 135° *from* the Eddystone lighthouse and 5 miles distant from it. All such bearings

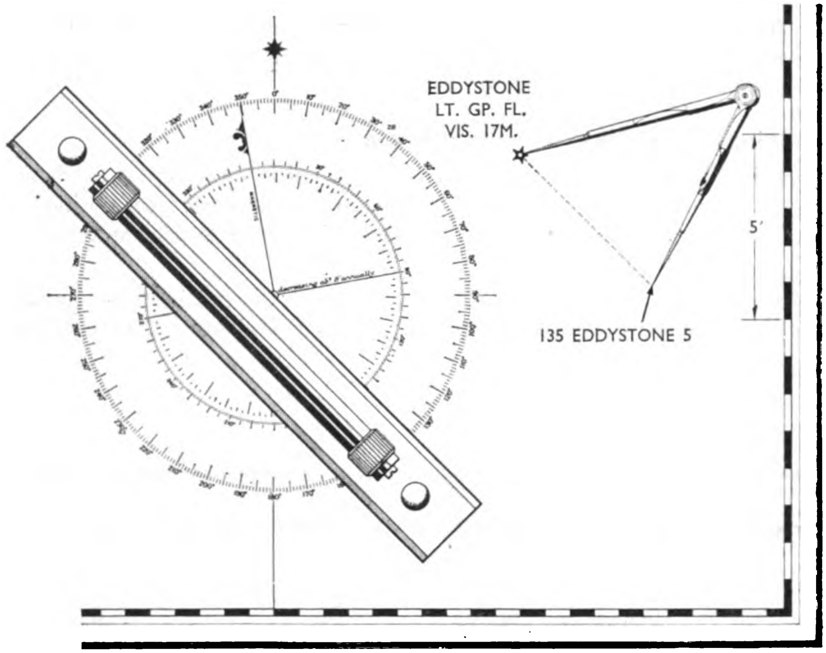


FIG. 18–2. Plotting a position by bearing and distance

are true bearings and the distances are in nautical miles.

Most charts have printed on them one or more compass roses from which a line of bearing can be drawn with the aid of a parallel ruler. Each rose has an inner and an outer circle of graduations; the graduations on the outer circle show true directions, and those on the inner circle show magnetic directions for the year in which the chart was published, the variation and its annual change being indicated on this circle.

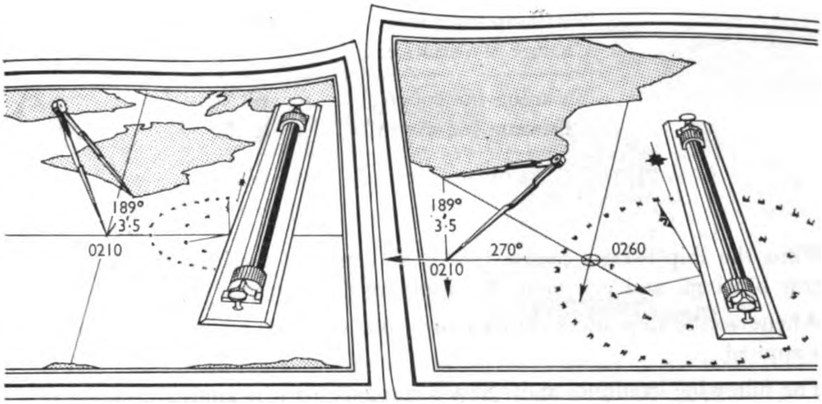
The distance scale is the scale of latitude at the side of the chart, one minute of latitude being equal to one nautical mile. It is important to remember that this scale on a chart alters with the latitude, and that the distance should therefore be measured off that portion of the latitude scale which is abreast the position which is to be recorded.

To record the position quoted above, first measure five miles from the latitude scale with a pair of dividers, then place the parallel ruler over the nearest compass rose on a bearing of 135°; now move the ruler until one edge passes through the Eddystone lighthouse, and lay off the distance with the dividers in the direction of 135° *from* the lighthouse (fig. 18–2).

Transferring a position from one chart to another

When planning a passage from one place to another and when on passage it is frequently necessary to transfer a point on the planned track, or the ship's position, from one chart to another.

The scale of one chart may be different from that of another, and a position



SHIP STEERING 270° TRACK TRANSFERRED TO SECOND CHART (SMALL SCALE).

SHIP STEERING 270° TRACK RUNS OFF FIRST CHART (LARGE SCALE)

FIG. 18–3. Transferring a position from one chart to another

should therefore be laid off by its bearing and distance from some object common to both charts and checked by its latitude and longitude.

To lay off and take off courses and bearings from a chart

When the planned tracks have been pencilled on a chart, the true and magnetic courses must be written alongside them. The methods used for converting compass courses to true courses or gyro-compass courses to true courses, and vice-versa, apply equally to bearings taken by compass to fix the position of the ship, as described later.

Gyro-compass courses and bearings must be corrected for any gyro error before they are laid off on a chart, and similarly, true courses and bearings taken off a chart must be corrected for any gyro error before they are applied to the gyro-compass (see Vol. I, Chapter 15).

Courses and bearings by magnetic compass, before being laid off on the chart, should be converted to true courses and bearings by applying the deviation obtained from the deviation card (see Vol. I, Chapter 15) and the variation, the latter being corrected for the change of variation indicated on the chart. Similarly, a true course or bearing taken off a chart must be corrected for the variation and change of variation, and for the deviation, before it is applied to a magnetic compass (see Vol. I, Chapter 15). These conversions from true to compass, and vice versa, may be made by combining the three corrections and applying them as a single, combined or total compass error. But it must be remembered that the total compass error will change with an alteration of course by the amount of change in the deviation. The following example shows how this combined error is calculated:

Variation is 15° 30′ *W* (1961), *increasing about* 7′ *annually. True course from chart is* 158°. *What is the compass error in* 1965*?*

By comparison between the true and magnetic roses the compass course will be about 170° C, on which course the deviation from the deviation table is stated to be 4° E.

Variation for 1961	$15\frac{1}{2}°$ W
Change of variation	$+\frac{1}{2}°$ W
Variation for 1965	16° W
Deviation for 170° C	4° E
Compass error	12° W

While the ship is on a course 170° C all compass bearings can be converted to true bearings, and vice versa, by applying this compass error of 12° W.

Whenever the ship alters course a new total compass error must be calculated and applied.

The following examples show how a compass error is applied:

The bearing of a lighthouse is 247° C by magnetic compass. What is the true bearing if the compass error for the course on which the ship is steering is 17° E?

Brg. of Lt. Ho.	=	247° C
Comp. err.	=	17° E ('compass least'—add)
True brg.	=	264°

The true course taken off a chart is 133°. *What is the compass course if the compass error is* 13° *W?*

True co.	=	133°
Comp. err.	=	13° W ('compass best'—add)
Comp. co.	=	146° C

To find the error of a gyro-compass or the deviation of a magnetic compass

Never miss an opportunity of checking the error or deviation of a compass by transits, particularly in small craft where unknown compass errors may have been introduced since the last table of deviations was made.

If an observer sees two objects in line he must be situated somewhere on the line which joins them. The objects are then said to be 'in transit'. If both objects are marked on the chart a position line can be drawn through them, and the true bearing can then be found from the nearest compass rose. If a compass bearing is now taken of the objects in transit and compared with the magnetic bearing calculated from the true bearing, the deviation of the compass for that particular direction of the ship's head can easily be found. In a ship fitted with a gyro-compass the error can be found by comparing the gyro-compass bearing with the true bearing on the compass rose. If the compass reading is more than the true bearing the gyro-compass error is 'high'; if it is less the error is 'low'.

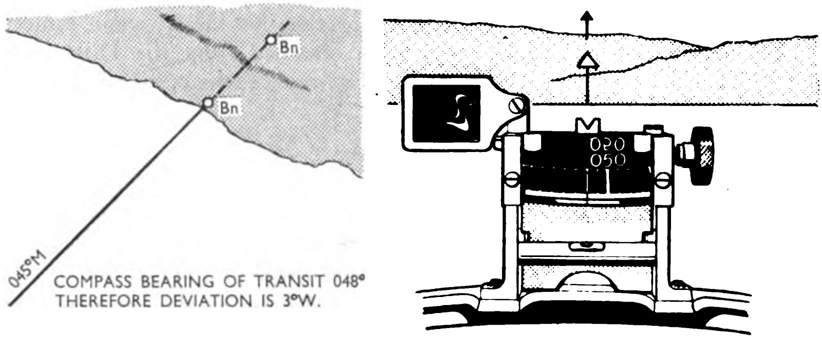


FIG. 18–4. Checking deviation of magnetic compass by a transit

EXAMPLE 1 (fig. 18–4)

From chart, beacons in line bear	035° (True)
Variation (corrected for year)	10° W
Therefore beacons in line bear	045° M (Magnetic)
From ship „ „ „ „	048° C (by mag. compass)
Deviation =	3° W

EXAMPLE 2

From chart, beacons in line bear	035° (True)
From ship „ „ „ „	032° (by gyro-compass)
Gyro error =	3° (low)

Recording a ship's position on a chart

A *fix* is the ship's position found from reliable observations of terrestrial objects, obtained either visually or by a radio navigational aid, and is shown on the chart by a circle with the time of observation against it, thus: ⊙ 1100.

An *observed position* is the ship's position found from reliable sextant observations of heavenly bodies, as explained in the *Admiralty Manual of Navigation*, Vol. II, and is shown on the chart by a circle with the time and the letters Obs. against it, thus: ⊙ Obs. 0530. When it is not possible to obtain the ship's actual position by observations or by fixing, a theoretical position can be worked up from the last observed position or fix.

A *dead reckoning* (*D.R.*) position is the ship's position obtained by plotting on from the last fix, or observed position, the speed made good through the water along the compass course steered, and is shown on the chart thus:

0630 ——|—— 0730 ——|——

An *estimated position* (E.P.) is the most accurate that the navigator can obtain by calculation and estimation only. It is obtained from the D.R. position adjusted for the estimated effects of 'wind across', currents and tidal streams, and is shown on the chart thus: △ 0800.

Plotting the ship's track

Having established the intended track of the ship on the chart, the navigator cannot assume that, because his compass is correct, his ship will necessarily stay on that track and make good the expected speed over the ground.

Plotting the ship's track on the chart is complicated by the effects of current or tidal stream and wind, so her course and speed through the water (which are obtained from the compass and the log or other method of speed recording) will by no means be the same as her course and speed over the ground (which the plotted track is required to show). To plot the ship's track on the chart it is necessary to know the course and speed made good over the ground.

The ship's track should therefore be plotted in two steps as follows:

1. Starting from the last known position, plot the course steered through the water and the distance steamed along that course in the intervening time, thus arriving at a dead reckoning position.
2. Plot in the correct direction from the dead reckoning position the combined effect of the current or tidal stream and wind for the period being considered. The position now arrived at is the estimated position.

The effects of current or tidal stream and wind must be considered before proceeding with the actual plotting on the chart. Currents must not be confused with tidal streams. Information on currents is obtained from the ordinary Admiralty charts, from special Admiralty Current Charts, and from the *Sailing Directions*. Information on tidal streams is to be found on Admiralty charts and in special tidal atlases. The navigator should always note down and remember the times of high and low water, and constantly revise his assessment of the set and rate of the streams according to the time and place, remembering that the slower the speed of his ship the greater will be the allowance necessary to make good his desired course.

The effect of wind can be estimated only by experience of the particular vessel's behaviour. It is only necessary to judge the amount the ship has been moved to one side or the other of her course, because the effect of the wind on the speed of the ship is allowed for in the speed made good through the water as shown by the log. Leeway, which depends on the draught of a ship compared with her freeboard and on the extent to which her superstructures offer resistance to the wind, is often cancelled out by her tendency to 'bore to windward'; particularly is this so with a light, shallow draught vessel in a quartering sea: but an experienced helmsman will ensure that the average course steered is that ordered, by taking care whenever the ship is forced to windward of her course to swing her back an equivalent amount to leeward of it.

The following example, illustrated in fig. 18–5, is given to show how the effects of current or tidal stream and wind are allowed for when the track is plotted.

Suppose that at 0900 the ship is known to be in latitude 57°45'N, longitude

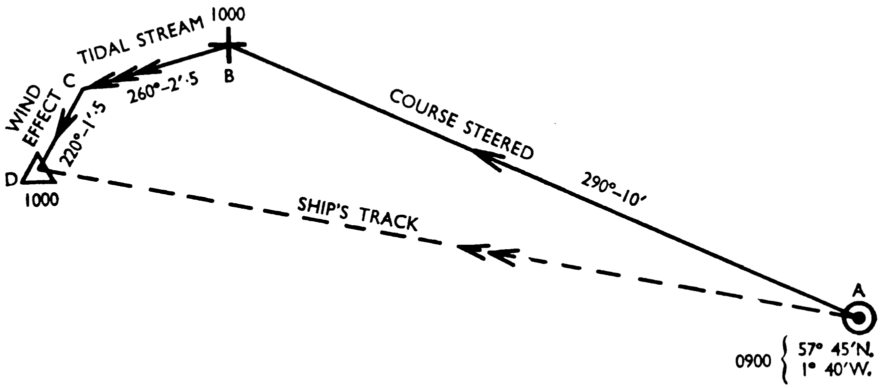


FIG. 18–5. Plotting the ship's track

1°40′W, steering a course 290° and making good a speed of 10 knots through the water. From the tidal stream atlas (or from information given on the chart) it is found that at 0900 the tidal stream should be setting 260° at a rate of 2·5 knots. The wind is N.E., force 8.

Plotting the course steered and the speed through the water. The starting point *A* may be a fix or an observed position. Place the parallel ruler on the nearest compass rose so that its edge passes through the centre of the rose and through 290° (the course being steered) on the outer circle of graduations, and for increased accuracy make sure that it also passes through 110°, the reciprocal of the course. With the parallel ruler transfer this direction so as to pass through the starting point *A*, and draw a line of sufficient length to show the whole run; this will be the ship's course. The log will give the distance steamed through the water between 0900 and 1000. In this example the speed is 10 knots, so measure off 10 miles from the scale of latitude corresponding to the latitude of *A*, and lay it off from *A* along the course, thus obtaining the point *B* which is the dead reckoning position at 1000, and therefore marked thus: + 1000.

NOTES

(i) If a magnetic compass is used the compass course must be corrected for variation and deviation and laid off as before.

(ii) If the dead reckoning position has been obtained from a log reading, the effects on the ship's speed of a head or a following sea or wind will have been taken into account. If the position has been estimated from the revolution table these effects must be allowed for together with the state of the ship's bottom.

Plotting on, from the dead reckoning position, the effect of any current, tidal stream or wind (other than that already allowed for in the speed made good through the water). It is now necessary to consider the tidal stream, which is setting 260° at 2·5 knots, and the effect of the wind, which is N.E. force 8. It is estimated from experience that the effect of the wind will set the ship in a 220° direction at 1·5 knots.

From the 1000 D.R. position *B* lay off a line *BC*, 260°, 2·5 miles, to represent the amount the ship will be set by the tidal stream, and mark it with three arrows.

From C lay off a line CD, 220°, 1·5 miles, to represent the drift of the ship due to the wind.

We now have a scale diagram showing what happens during one hour's run. The point D is the estimated position at 1000, and is therefore marked thus: △ 1000. The dotted line AD is the track which it is estimated the ship will make good over the ground. Until a definite fix or reliable observed position is obtained, this estimated position should not be erased, even though subsequent checks, such as soundings, or a single position line may cast doubt upon its accuracy.

Shaping a course, allowing for a tidal stream

Of more importance to the navigator is the problem of shaping a course that will keep a ship on a planned track, allowing for a tidal stream.

EXAMPLE

What course must a ship steer when steaming at 12 *knots to make good a course* 090° *if it is estimated that the tidal stream is setting* 040° *at* 3 *knots?*

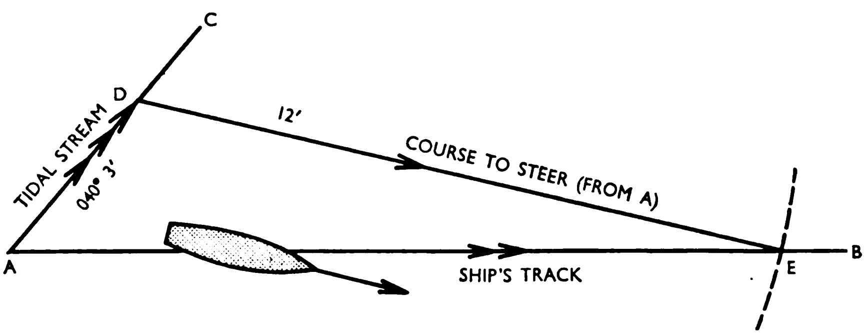


FIG. 18–6. Shaping a course, allowing for a tidal stream

Lay off the course to be made good, 090° (AB in fig. 18–6). From A lay off the direction of the tidal stream, 040° (AC). Along AC mark off AD equal to the distance the tidal stream sets in any convenient interval of time on a chosen scale; in this example a one-hour interval has been allowed, so that AD will be three miles.

With centre D and radius equal to the distance the ship steams in the same interval of one hour (12 miles), describe an arc to cut AB at E. Then join DE, which will be the course to steer.

This course is actually steered from A, and AE is the distance made good in an 090° direction in one hour and is marked with two arrowheads.

Reaching a position at a definite time, allowing for a tidal stream

EXAMPLE

What course must a ship steer, and at what speed must she steam, to proceed from a position A to an anchorage B in 1½ *hours, allowing for a tidal stream setting* 150° *at* 3 *knots?*

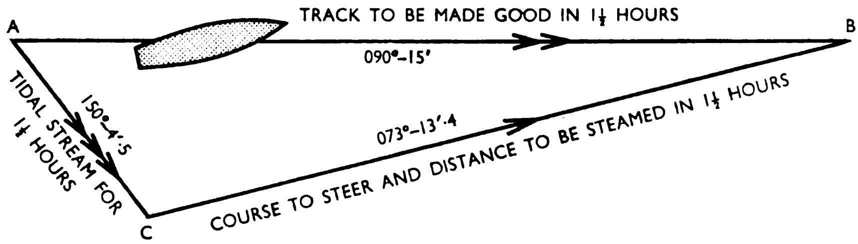


FIG. 18–7. Estimating course and speed to reach a position at a definite time, allowing for a tidal stream

Join *AB*, as shown in fig. 18–7. This determines the course and distance to be made good in 1½ hours, i.e. 090°, 15 miles.

From *A* lay off the direction of the tidal stream, 150°, and the distance it sets in 1½ hours, *AC*, which is 4½ miles. Join *CB*. Then *CB* represents the course to steer, 073°, and the distance the ship must steam in 1½ hours, 13·4 miles. The speed of the ship should therefore be 8·9 knots.

ESTABLISHING THE SHIP'S POSITION

Position lines

A position line is any line drawn on a chart on which the ship's position is known to lie. It may be straight or curved. It may be obtained from a sextant observation of the Sun or Moon or from individual stars, or from a compass bearing of a landmark or seamark, or from a line of soundings, or from the range of a powerful light when first sighted in good visibility.

If two or more position lines lying in different directions are obtained simultaneously, the position of the ship should be at the point of intersection of the lines, and this position is called a 'fix'.

A position can be found by using two position lines obtained at different times by transferring the first position line the amount that the ship has steamed in the interval of time, adjusted for tidal stream, current and wind; it is then known as a 'running fix'.

It is usual to mark a position line drawn on the chart from a bearing of a terrestrial object with a single arrow at the outer end; if it is transferred it is marked with a double arrow at both ends.

The navigator of a small craft, with the aid of charts, compass, watch, lead line, tide tables and some means of estimating speed, can obtain position lines by:

(i) a transit
(ii) a compass bearing
(iii) a horizon range of a powerful shore light
(iv) soundings.

The navigator of a big ship, who has the additional aids of sextant, log, echo sounding, radar and radio navigational aids, can obtain position lines from a

much wider range of methods. More essential than elaborate apparatus, however, are accuracy, alertness and a dislike of taking anything for granted. In this chapter only those methods which are available in small craft are described.

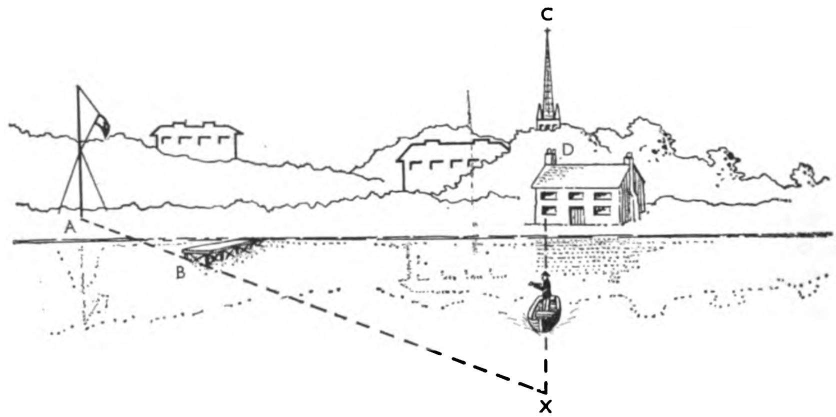


FIG. 18–8. A simple example of the use of transits

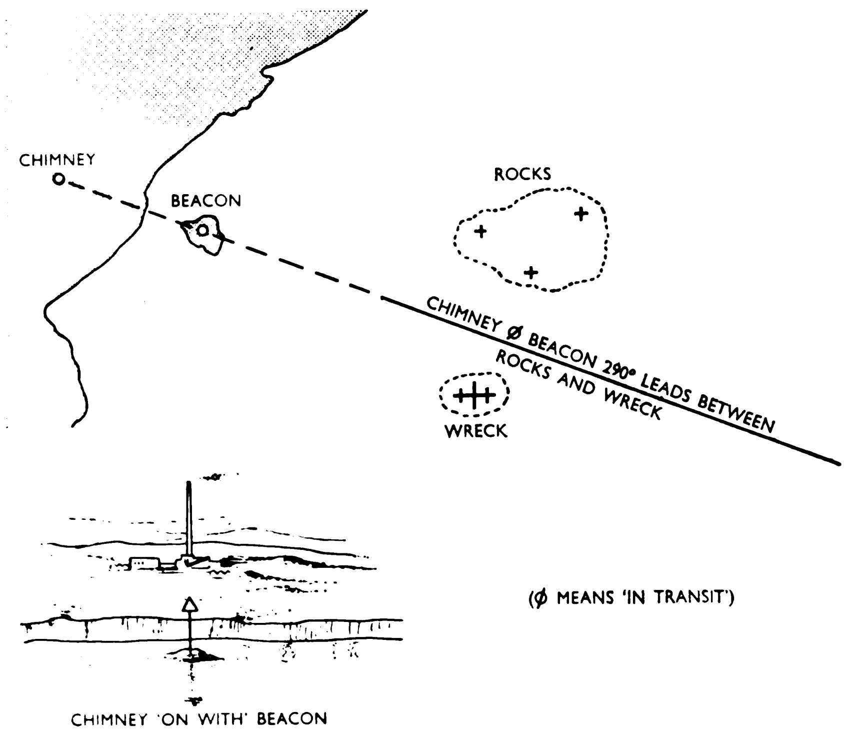


FIG. 18–9. Leading marks and leading line

Transits

The method of checking the accuracy of a compass by a transit has already been described. Now let us see how transits can be used to establish the ship's position or prevent the navigator from approaching a danger.

The simplest method of establishing a position without the aid of a compass or chart is shown in fig. 18–8. A fisherman has to abandon an anchor or some fishing gear at the position *X*. Before leaving this position he observes that objects *B* and *D* are in line with objects *A* and *C* respectively; he can therefore return later to the same spot to recover the gear by steering a course which keeps *D* and *C* in line until he sees *B* come into line with *A*.

Leading marks (fig. 18–9). Many harbour plans show two marks which, when kept in transit, lead the ship in the best channel. Such marks are called 'leading marks' and are shown on a chart by a line drawn through them called a 'leading line'. When the marks are in transit, i.e. when the chimney is 'on with' the beacon, take a compass bearing and compare it with that given on the chart.

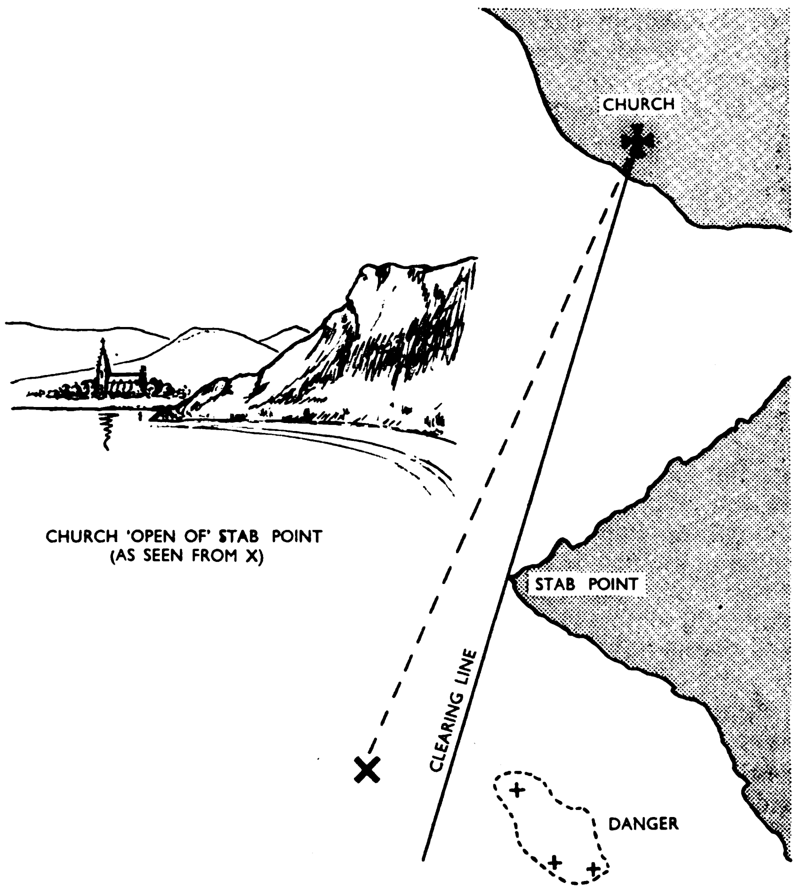


FIG. 18–10. Clearing marks and clearing line

This ensures that the objects seen in transit are the correct objects, and it also checks the error of the compass.

Clearing marks. When a hidden danger lies in the approach to an anchorage it will often be found that a 'clearing line' is drawn on the chart. This line leads clear of the danger and a ship must be in safe water if she keeps outside it, that is when the marks are kept 'open'. In fig. 18–10 the clearing marks are the church and Stab Point; the church must be kept 'open of' Stab Point.

Leading line and clearing line. When there is only one conspicuous object, a line of bearing drawn on the chart from that object may be used to lead between dangers or clear of them. The ship must then steer a course so that the object remains on the correct bearing. In fig. 18–11 the leading line 255° leads the ship safely between shoals, and the clearing lines of 245° and 265° show the limits of safety. The bearing of the lighthouse must not be less than 245° or more than 265° when entering or leaving this bay.

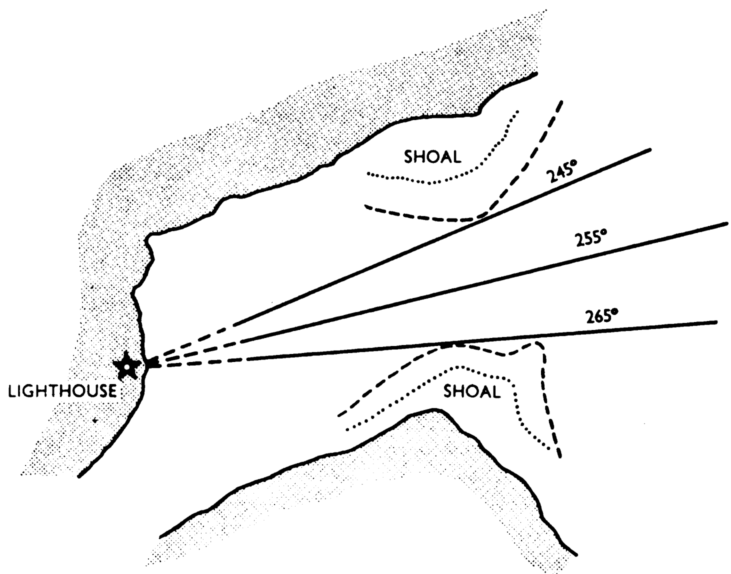


Fig. 18–11. Leading line and clearing line

FIXING BY POSITION LINES

The estimated position, as we have seen, is the position found from the course steered and the estimated speed through the water, corrected for any distance the ship has been moved by the tidal stream, current, wind and sea. This position is liable to error, in which case all subsequent plotting of the track will be affected. It is therefore always necessary for the navigator to fix the ship's position as often as possible by observations which provide definite position

lines. Any two such lines will give a fix, but a third position line should be taken as a check.

Before fixing the ship's position, identify all the objects you are going to use and make certain that they are marked on the chart. It is no use taking the bearing of one conspicuous object and then having to look about to select the others. When taking cross-bearings first note the names of the objects to be observed and write them down. After this the bearings should be taken as quickly as possible, and the time should be noted immediately after taking the last bearing. The most favourable circumstances are when the first object observed is nearly ahead and the third nearly abeam; the bearing of the latter will change rapidly, especially if it is near the ship, and unless the bearings are taken almost simultaneously it will be impossible to get a satisfactory cut.

When using a magnetic compass remember that the deviation which must be used to correct the bearings is the deviation for the direction of the ship's head when the observations were taken.

Selecting objects for a fix

When a ship's position is fixed by three bearings the objects selected should, if possible, lie so that their bearings differ by about 60 degrees; the position lines will then make a good cut. If it is only possible to fix by two bearings, the objects selected should lie so that their bearings intersect as nearly as possible at right-angles, as then the effect of any small error in taking the observations and laying them off on the chart is reduced to a minimum.

Always select objects near the ship in preference to distant objects, but a position line obtained from a bearing of a buoy, or of any other object liable to move from its charted position, should not be relied upon.

Fixing by cross bearings

When accurate lines of bearing of two different objects are obtained simultaneously the ship must lie at the point where those two lines intersect. Suppose that at 1015, from an observer on board a ship, a lighthouse bore 040° and a church bore 125°, as shown in fig. 18–12. If these two lines are drawn on the chart, the point of their intersection should be the ship's position at 1015. As, however, slight errors may arise in taking the bearings, and there may also be slight errors in the charted position of the objects, a third bearing, called a *check bearing*, should be taken. If all these bearings and the chart were accurate this bearing should pass through the point of intersection of the other two. In practice, however, owing to such errors it will be found that the three bearings, when plotted, form a small triangle known as a 'cocked hat' (shown shaded), in which the check bearing is that of the flagstaff bearing 075°.

If a cocked hat is reasonably small the position of the ship is usually taken as lying at its centre. If the cocked hat is large, however, the bearings should be taken and plotted again to ensure that the objects have been properly identified and that there was no error in correcting them. Then, if a large cocked hat still remains, the position of the ship should be taken as lying at the corner of the triangle which will place her nearest to danger, thus ensuring that subsequent alterations of course for rounding marks, etc. will have a probable safety margin.

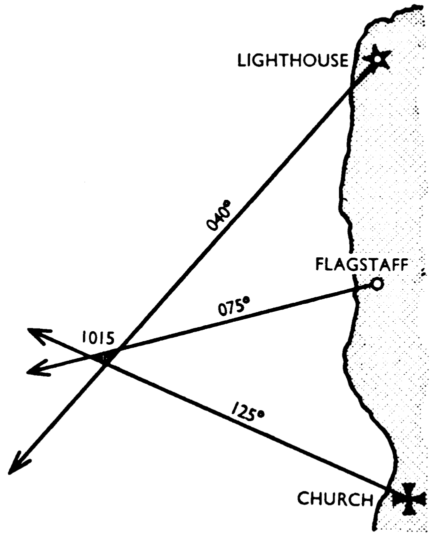


FIG. 18–12. Fixing by cross bearings

As the cocked hat may also be caused by unknown deviation or gyro error, every opportunity should be taken to check the deviation or error of the compass. The opportunity for a check on at least one direction of the ship's head arises whenever two charted objects are passed in transit.

Example of a bad fix by cross bearings. If the ship is on the circumference of a circle passing through the three objects, the three lines of bearing will always meet at a point, even when there is an unknown compass error. Any unknown compass error may therefore pass undetected and an incorrect position be recorded, as shown in fig. 18–13, where the compass error is 10° high.

Note that the conspicuous chimney should not have been used when there was a beacon on a nearly similar bearing much closer to the ship.

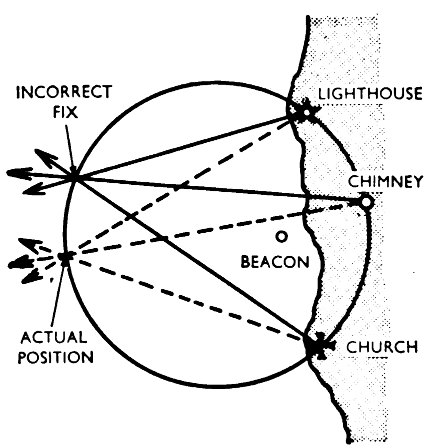


FIG. 18–13. Example of a bad fix by cross bearings

A running fix

It frequently happens that only one object can be seen, and so only one position line can be obtained, at a given moment. This one line can be used later to obtain a fix when a second bearing of the same object, or a bearing of another object, is taken.

EXAMPLE

A ship is steering 090° *at* 8 *knots. The tidal stream is estimated as setting* 135° *at* 3 *knots. At* 1600 *a lighthouse bore* 034°. *At* 1630 *the same light bore* 318°. *Find the position of the ship at* 1630.

Draw a line *ACE* in an 034° direction to pass through the light, as in fig. 18–14(i). This is the position line at 1600.

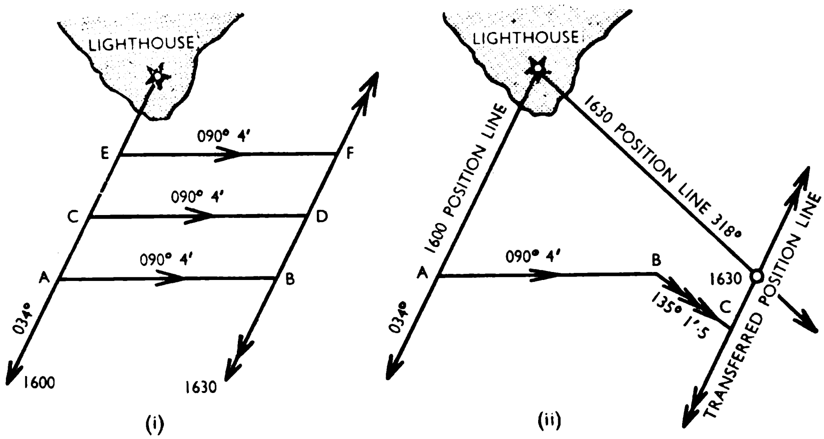


FIG. 18–14. A running fix: (i) first step; (ii) second step

Now suppose that three lines, *AB*, *CD* and *EF*, are drawn each in a direction 090° and each 4 miles in length (the distance run in half an hour); then if the ship is at *A* at 1600 she will be at *B* at 1630, provided that she is unaffected by wind, current or tidal stream. Similarly, if she is at *C* or *E* at 1600 she will be at *D* or *F* at 1630. Then, since *ACE* is the position line at 1600, *BDF* must be the position line at 1630—that is, the original position line has been transferred, and the new line is known as the 'transferred position line'. This is parallel with the original position line and is distinguished by two arrowheads at each end.

But the ship is set by the tidal stream, current or wind during the run, and therefore the point through which to draw the transferred position line must be arrived at by two steps, as shown in fig. 18–14(ii). First lay off from any point on the original position line the course and distance steamed by the ship in the interval (*AB*). Then from the end of this line, at *B*, lay off *BC* to represent the direction and distance the ship is estimated to have been set in the interval by tidal stream, current or wind. The position line should now be transferred to pass through *C* and be marked with two arrowheads at each end. If the allowance made for the tidal stream, etc. has been accurately estimated, the ship must be at some point on this transferred position line at 1630. At 1630 the

same light bore 318°, and this position line should now be drawn. The point where the transferred position line drawn through *C* cuts this second position line is the ship's position at 1630.

It must be emphasised that the accuracy of a running fix depends entirely on the correct estimation of the ship's track between the two bearings.

Fixing by a bearing and sounding

On approaching the land in places where the depth changes fairly rapidly, an approximate position can be found by observing a bearing of a charted landmark and at the same time obtaining soundings (fig. 18–15).

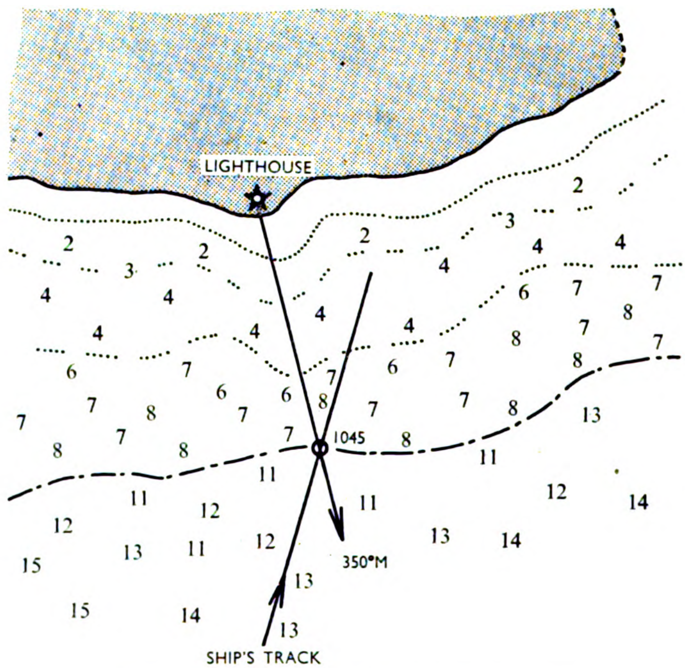


FIG. 18–15. Fixing by bearing and sounding

Make allowance for the height of the tide before comparing the soundings with the chart; select a bearing which crosses the fathom lines as nearly as possible at right-angles; and bear in mind that the fix will not be reliable unless the fathom lines are very clearly defined.

Approximate position by bearing and horizon range of a light

This method is most useful for finding the distance of a powerful light when it appears above the horizon or dips below it. The point at which a light thus appears or dips may be checked by the observer changing his height of eye.

The height of a light given on the charts and in the Light Lists is the height of the centre of the lantern above the level of mean high water springs. The

charted or listed geographical range at which a light may be seen in clear weather is expressed in sea miles for an observer's height of eye of 15 ft, and when the level of the sea is that of M.H.W.S., i.e. when the height of the light above the level of the sea is about the least. The light can therefore be seen earlier, and thus from a greater distance, if the tide is appreciably lower than M.H.W.S., or if the eye of the observer is more than 15 ft above the sea. A Geographical Range Table, which gives the ranges from which a light may be seen for various heights of the light and the observer, is included at the beginning of each volume of the *Admiralty List of Lights*.

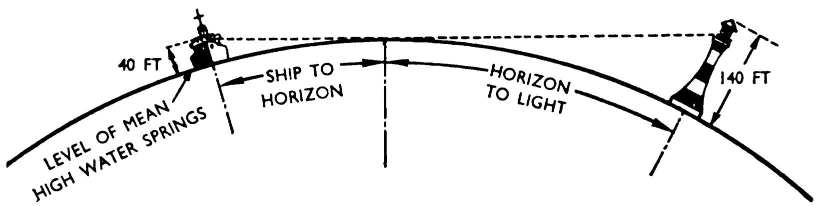


FIG. 18–16. Approximate position by bearing and horizon range of a light

For example, the geographical range at which a powerful light, whose height is given on the chart as 140 ft, will appear above or dip below the horizon on a clear night when an observer, whose height of eye is 40 ft, is 21.0 sea miles from the light. Fig. 18–16 shows the relative positions of the ship and lighthouse at this range.

PREPARATION FOR A PASSAGE

Before making a passage, careful preparation is required. This includes:

(i) collecting all available information regarding the navigational aids and dangers which may be encountered, and noting the times at which it is expected that they will be encountered or passed;

(ii) selecting a suitable track for the ship, and noting which part will be covered in daylight and which in darkness;

(iii) checking the accuracy of the compass and log;

(iv) making sure that the charts are corrected from the *Admiralty Notices to Mariners*.

The following publications contain all the information required:

The Mariner's Handbook contains information on Admiralty charts and navigational publications, general navigation, general meteorology and ice.

The Admiralty Tide Tables, which are published annually, give the times and heights of high and low water at the principal ports.

The Admiralty Sailing Directions, which are usually called 'Pilots', e.g. the 'Channel Pilot' and the 'North Sea Pilot', give very detailed descriptions of the coasts with their harbours, ports, navigational aids, and dangers, and directions for passing coastal dangers and entering ports and harbours, thus amplifying the information indicated by the charts. The latest Supplement to a 'Pilot' must always be consulted.

The Admiralty Lists of Lights give more complete particulars of shore lights, light-vessels and fog signals than are given on the charts; and they may contain temporary information not given on a chart.

ON PASSAGE

Care and use of charts at sea

The surface of the chart can best be preserved (and plotting will be much clearer) if a soft pencil and a soft rubber are used; on no account should pen and ink or indelible pencil be used for plotting. The chart should always be folded along its proper creases and kept dry. In wet weather a towel placed along the front of the chart table to lean on, and removal of your cap before leaning over it, will save the chart from damage.

Take care of the parallel ruler and of the points of dividers. A parallel ruler is less likely to slide or roll about if turned over on its back when not in use.

Coasting

Lights. Never pass a light without checking its period and characteristics.

Light-buoys. Do not rely on light-buoys alone, because the light sometimes fails.

Buoys and seamarks. Do not fix your position by buoys when other objects are visible close to the ship. Remember that the buoys marking a shoal are frequently changed as the shoal extends, and they may be moved occasionally by local authorities before there is time for the information to be embodied on the charts. On the other hand, after a notice concerning the movement of buoys has been promulgated and embodied on a chart, there may have been some unforeseen delay in putting the notice into effect.

Bays. Remember that currents and tidal streams often follow the coastline and consequently set into bays and bights.

Fixing the ship

1. Fix frequently when possible. Jot down the bearings and times of each fix, together with the reading of the log, in your notebook. Many fixes may eventually be unnecessary, but fog or rain squalls may suddenly reduce visibility without warning, and the last fix obtained then becomes of the greatest importance.

2. Always select objects close to the ship in preference to distant objects. It is preferable to fix at regular intervals and so get a constant check on the ship's track.

3. Always use the largest-scale chart.

4. Having fixed the ship's position on the chart, always write the time against it and project from it the ship's future track.

The position of the ship should always be marked on the chart at frequent intervals, by dead reckoning if no fix is possible.

Write the course on the middle of the line which represents it on the chart.

5. Keep a careful and continuous reckoning on the chart, and in your notebook, throughout the time the ship is at sea.

6. Do not have two charts on the table at the same time, because confusion between the scales may arise.

7. When passing between islands use objects which are all on one hand or all on the other whenever possible; the two islands may have been separately surveyed.

8. When taking the bearing of the edge of a low point of land, considerable error may be introduced unless the high water mark (which is the charted coastline) is clearly defined. The error is emphasised when there is a large tidal range and the beach gradient is slight.

9. When the only objects available for taking bearings are mountain summits, or distant or inconspicuous marks, your fix may be very inaccurate and should be treated with great caution, or even disregarded if there is no other reason for mistrusting your estimated position.

10. Great care is necessary when transferring from one chart to another, because they may be drawn on different scales. Transfer your position by bearing and distance of a well-charted point common to both charts, and then check for any major error by verifying that the latitude and longitude of your position are the same by each chart (fig. 18–3).

Safe distance at which to pass dangers. The general rule in coasting is to pass close enough to the shore to make certain of seeing and identifying all prominent landmarks, such as lighthouses and beacons, and thus be able to obtain frequent fixes.

A course should be steered which will not converge with the coast, so that if fog or mist should suddenly obscure the landmarks the ship can continue on her course without running into danger. It requires experience to decide at what distance the ship's track should pass clear of coastal dangers. Beware of the half-way position, which is not close enough to the land to identify its features easily and yet not far enough out to ensure being well clear of all dangers. As a rough guide, the planned track of the ship should pass outside the 3-fathom line when the draught is 10 ft or less; and outside the 5-fathom line when the draught is between 10 and 20 ft. When there are dangers near the coast they should be given a clearance of at least one mile by day and at least two miles at night. These distances will have to be adjusted for the prevailing weather, tidal streams and currents expected, the nature of the coast and the probable opportunities for fixing the ship's position, both by day and at night.

Sighting other ships. When altering course to conform with the rule of the road, always:

(i) alter the course in plenty of time;
(ii) alter course sufficiently to make your intention clear;
(iii) take care not to resume your original course until all risk of collision is past.

Do not assume that every vessel sighted steering a similar course must be bound for the same destination as you are, or that other vessels sighted are navigated with more skill than your own.

Fog and thick weather

When it is seen that the ship is about to enter fog, note the bearing and approximate distance and course of any ships in sight; and, if possible, obtain a fix. Before entering a fog the following precautions should always be taken:

1. Reduce to a moderate speed. Moderate speed is held to be 'such a rate of speed as will enable a vessel, after discovering another vessel meeting her, to stop and reverse her engines in sufficient time to prevent any collision from taking place'. (See Annex to the International Regulations—Chapter 20.)
2. Operate radar, if fitted.
3. Station lookouts both on the forecastle and aloft.
4. If in soundings, start sounding.
5. Have an anchor ready for letting go when in the vicinity of land.
6. Order silence on deck.
7. Close watertight doors in accordance with ship's standing orders.
8. Start the prescribed fog signal and listen for fog signals of other ships.
9. Warn the engine room.
10. Memorize the characteristics of navigational fog signals to be expected.
11. If in any doubt about the ship's position, alter course at once to a safe course, parallel to or away from the coast. If this is not possible, stop and anchor.

Fog signals from shipping. When hearing before the beam the fog signal of a vessel the position of which is not certain, if circumstances permit you should stop engines and then navigate with caution. Note in the log the exact time at which the engines are stopped.

Article 15 of the *International Regulations for Preventing Collisions at Sea* states that 'Power-driven vessels shall sound at intervals of *not more* than two minutes . . .' their appropriate sound signals. Make your signals regularly, clearly, and deliberately in accordance with this article. If possible, time them so as not to coincide with the signals of another vessel, but having once started a signal on no account break off in the middle of it in order to listen to the other vessel's signal.

The sound signals prescribed in Article 15, which are intended to announce the presence of a ship, must not be confused with those in Article 28, which are made only to a ship in sight to tell her how you intend to direct your course in compliance with the Steering and Sailing Rules.

Fog signals marking navigational dangers. Do not rely on hearing a fog signal from a light-vessel, lighthouse or buoy, because the direction of sound is often deflected by fog and there are often large areas into which the sound does not penetrate. Bell buoys and whistle buoys are also unreliable in calm weather, as their sound signals may be operated by the motion of the sea.

PILOTAGE IN NARROW WATERS

When rounding points of land, spits, shoals, buoys and light-vessels, allow plenty of room; cutting corners is dangerous. When passing a buoy it is easy to see which way the tidal stream is setting by observing the 'wake' made by the buoy. Similarly, the direction in which a light-vessel is heading will, unless she is moored head and stern, indicate the direction of the tidal stream if the wind is not strong enough to swing her across it.

When rounding buoys and light-vessels to windward and against the stream, they should always be given a wide berth. A ship passing near any light-vessel that has clear water on all sides of her should pass downstream of her, because underestimation of the strength of the tidal stream may result in collision.

Always compare the name, shape, colour and topmark of a buoy with that shown on the chart, to avoid the possibility of mistaking one buoy for another.

Low-lying land

When the land is too indistinct to fix the ship's position by bearings of shore objects, fix by bearings of beacons and light-vessels, if available, in preference to bearings of buoys.

Where the shore is distant and low-lying (as in the Thames Estuary, for example) buoys may be the only guide. Before making a passage in such a locality, especially if the weather is likely to be thick, lay down on the chart all your required courses and make due allowance for the tidal stream that should be running at the time when you should pass them. Note in advance each course and the distance to be run on it, also the time it will take to steam from buoy to buoy or from beacon to beacon. Then check the time and course as you proceed. If, after passing one buoy, the calculated time of your arrival at a second buoy elapses but you have not sighted it, proceed with the utmost caution and stand by to anchor.

Fog in a narrow channel

In fog it will be necessary to lay your ship's course close to the starboard-hand buoys instead of in mid-channel, and to reduce speed; consequently your courses from buoy to buoy, adjusted for tidal stream, current or wind, must be worked out afresh and entered in the notebook.

Always carefully check the type of each buoy sighted. When departing from a buoy, work out accurately the time at which the ship should pass and sight the next buoy at her present course and speed. If at the end of that time the next buoy is not in sight, stop the ship and, if possible, anchor, because when the ship's course has been laid close to the buoys there is a very small margin of safety.

THE SHIP'S LOG

The log should be written up at the time when each incident recorded actually occurs. Full instructions for writing up the log and various meteorological tables are given inside the cover. The following notes amplify the instructions.

Distance run is an estimation of the distance the ship has run through the water in each hour or on each course, taking into account the revolutions, the log reading, the state of the bottom and the effect of the wind.

Barometer readings. The reading of a mercurial barometer should be corrected by the barometer correction slide before entry in the log. An aneroid barometer should be adjusted to give the barometric pressure at sea level and therefore no correction is needed for the entry in the log.

Anchor bearings should be the bearings of shore marks from the position of the anchor. If, subsequently, anchor bearings are checked to ascertain whether the ship is dragging, allowance must be made for the distance between the anchor and the bridge.

CHAPTER 19

The Weather

Although only the few remaining sailing craft now depend upon the vagaries of the wind to make their passages, an understanding of weather is still essential to every seaman. The aim of this chapter is to present a brief outline of the facts concerning weather which every seaman should know, and to indicate the necessity for accurate, careful and punctual records of wind, sea and sky, and of the readings of the various meteorological instruments supplied to H.M. ships. The subject is dealt with more fully in the *Admiralty Manual of Navigation*, Vol. II.

THE ATMOSPHERE

The phenomena that we describe as weather are caused by movements and other changing conditions of the atmosphere, or that layer of air which surrounds the Earth and contains oxygen, nitrogen and small amounts of other gases and also varying amounts of water vapour which cause cloud, rain and fog and make the temperature equable. The movements of the atmosphere are caused by the heat of the Sun, the rotation of the Earth, the distribution of land and sea, and some other more complex factors.

Atmospheric pressure. Air has a measurable weight or pressure. At sea level the pressure exerted by the air overhead is about 15 lb per square inch, and fluctuations in this pressure can be accurately measured by means of the barometer. For various reasons atmospheric pressure is measured, not in pounds per square inch, but in dynes per square centimetre, commonly termed *millibars*, and the scales of all modern barometers are graduated in these units. The average pressure at sea level is about 1013 millibars.

Three types of barometer are in general use, namely, the mercurial barometer, the aneroid barometer and the barograph, which are described at the end of this chapter.

It has long been known that changes in atmospheric pressure are associated with changes of the weather, especially of the wind; hence the importance of keeping an accurate record of barometric readings. Broadly speaking, high pressure is associated with fair (though not always sunny) weather and light winds, while low pressure is usually accompanied by strong winds and rain.

Wind and the Beaufort wind scale

Wind is the result of a difference of pressure between two adjacent areas. The relationship between wind direction and the distribution of pressure can be expressed as follows: *If you face the wind when in the northern hemisphere, pressure will be low on your right hand and high on your left, and in the southern hemisphere it will be low on your left and high on your right.*

Wind is always named and recorded by the direction from which it is blowing reckoned from True North; it should be logged to the nearest 10° of the compass.

Its strength is estimated from the Beaufort Scale, given below and at the beginning of the Ship's Log; but it is the speed that is written in the ship's log.

BEAUFORT WIND SCALE

Wind Force (Beaufort)	Speed in knots	Descriptive Term	Coastal Criterion	Sea Criterion
0	Less than 1	Calm		Sea like a mirror.
1	1–3	Light air	Fishing smacks just have steerage way.	Ripples with the appearance of scales are formed, but without foam crests.
2	4–6	Light breeze	Wind fills the sails of smacks, which then make good 1 to 2 knots.	Small wavelets, still short but more pronounced; crests have a glassy appearance and do not break.
3	7–10	Gentle breeze	Smacks begin to heel and make good 3 to 4 knots.	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered 'white horses'.
4	11–16	Moderate breeze	Good working breeze. Smacks carrying all sail heel over considerably.	Small waves, becoming longer; fairly frequent 'white horses'.
5	17–21	Fresh breeze	Smacks shorten sail.	Moderate waves, taking a more pronounced long form; many 'white horses' are formed (chance of some spray).
6	22–27	Strong breeze	Smacks have double reef in mainsails. Care required when fishing.	Large waves begin to form; the white foam crests are more extensive everywhere (probably some spray).
7	28–33	Near gale	Smacks remain in harbour, and those at sea lie to.	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	34–40	Gale	All smacks make for harbour if near.	Moderately high waves of greater length; edges of the crests begin to break into sprindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	41–47	Strong gale	—	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	48–55	Storm	—	Very high waves, with long, overhanging crests. The resulting foam, in great patches, is blown in dense white streaks along the direction of the wind. On the whole, the surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.

continued overleaf

BEAUFORT WIND SCALE—*continued*

Wind Force (Beaufort)	Speed in knots	Descriptive Term	Coastal Criterion	Sea Criterion
11	56–63	Violent storm	—	Exceptionally high waves (small and medium-sized ships might for a long time be lost to view behind the waves). The sea is completely covered with long white patches of foam lying along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility affected.
12	64 and over	Hurricane	—	The air is filled with foam and spray. Sea completely white with driving spray; visibility very seriously affected.

When judging the force and direction of the wind at sea, due allowance must be made for the speed of the ship, and the direction of the wind must be obtained by looking at the waves and not at the funnel smoke, a flag or masthead pendant.

When the direction of the wind changes in a clockwise direction (e.g. from S.W. to W.) it is said to *veer;* when it changes in an anti-clockwise direction (e.g. from S.W. to S.) it is said to *back.*

Sea state code

Code Figure	*Description*	*Mean Maximum Height of Sea Waves (in feet)*
0	Calm (glassy)	0
1	Calm (rippled)	0–1
2	Smooth (wavelets)	1–2
3	Slight	2–4
4	Moderate	4–8
5	Rough	8–13
6	Very rough	13–20
7	High	20–30
8	Very high	30–45
9	*Phenomenal	over 45

* As might exist at the centre of a hurricane.

Temperature

As already stated, the heat of the sun is a primary cause of motion of the atmosphere. An important consequence is that the weather is intimately bound up with changes of temperature; the wind may blow warm or cold in ways with which we are all familiar.

Different substances require different amounts of heat to produce a given change in temperature. The amount of heat required to raise the temperature

of water is two or three times greater than that required to raise the temperature of an equivalent volume of land by the same amount, and conversely, water yields from two to three times more heat than land when the temperature falls. The sea is therefore usually cooler than the adjacent land surface in summer or in hot regions, and warmer in winter or in cold regions.

Temperature is measured by means of a *thermometer*, which is described on page 557. At sea, both the temperature of the air and that of the sea surface are important, and different thermometers are provided for measuring each.

Humidity

The amount of water vapour present in the air varies from place to place and from time to time, and is an important factor in determining the nature of the weather. The amount of water vapour that the air can hold in an invisible state is limited, and it varies with the temperature. Warm air can hold more water vapour than cold air; when the air contains as much water vapour as it can hold at a given temperature it is said to be 'saturated'. If the temperature is lowered further, or more water vapour is added to the air, the surplus condenses into minute but visible drops of water, which constitute cloud, mist or fog.

Humidity is measured with a *hygrometer*, the commonest form of which is the 'wet and dry bulb thermometer', described on page 558. When the air is dry the wet bulb reading is several degrees below that of the dry bulb, but when it is saturated both will read the same and fog may then be expected.

Cloud

As explained in the preceding paragraph, when air is cooled below its saturation point the surplus water vapour condenses into visible droplets of water. Such condensation occurs in the atmosphere when there is cooling due to uplift and results in the formation of cloud. It is largely upon the manner of uplift that the type of cloud depends.

Air is often heated in its lower layers by its passage over a relatively warm land or sea surface. This causes it to expand, become lighter and rise (in the same way that warm water rises in the hot-water system of a house). As the air rises it expands further because of the decrease in pressure, and cools because of its expansion. If this cooling is continued beyond the point at which the air is saturated, cloud results. Clouds formed in this way are of the *cumulus* type, with flat, horizontal bases and rounded cauliflower heads which sometimes spread out at great heights into the shape of an anvil.

Where two masses of air from different sources and with different characteristics meet, boundary lines are formed where the colder and heavier air runs under the warmer and lighter air and compels it to rise. As in the previous case, the expansion and cooling of this air results in the formation of cloud, which spreads as a more or less continuous layer of *stratiform* cloud.

Air may also be forced to rise up the sides of mountains and high ground towards which the wind is blowing. The consequent expansion and cooling of the air again leads to the formation of stratus-type cloud if the ascent of the air is sufficient to cause condensation.

Rain, snow and hail

If the cooling process which gives rise to cloud-formation is continued the droplets of which the cloud consists grow in size until they become too heavy to remain suspended in the air, and they therefore fall to the ground as very fine rain or drizzle. If the droplets are held aloft by upward currents of air they grow by agglomeration and eventually fall as raindrops. When very strong up-draughts exist, as in large cumulus-type clouds, the drops become very large before falling as heavy showers of rain or, under certain conditions, as hail. The latter is caused by very strong up-draughts carrying the raindrops above the freezing-level, where they turn into continually growing balls of ice which eventually fall to the ground as hailstones. Thunderstorms are often accompanied by hail, because they also are caused by very strong up-draughts extending to great heights.

If the temperature at which condensation actually takes place is below freezing-point the droplets form as ice crystals, which grow and become snowflakes. Snowflakes often melt and change to raindrops before reaching the ground; as a rough guide, snow rather than rain is likely if the air temperature at ground or sea level is below 3°C (37°F).

Fog and mist

The cause of fog and mist is fundamentally the same as that of cloud, i.e. the cooling of air below the temperature at which it is saturated. In cloud the resulting condensation into visible particles takes place aloft, but in fog or mist the condensation occurs on the surface of the sea or ground. The difference between fog and mist is merely one of degree. Visibility of under 1000 metres (approximately 5 cables) constitutes a fog. Mist is recorded when the visibility is over 1000 metres but is perceptibly reduced by the presence of water droplets.

In the open sea almost all fog is caused by warm, moist air blowing over a relatively cold sea surface, whereby the lower layers of the air are chilled. These sea fogs are therefore most common in spring and early summer, at which seasons the sea surface temperature is lowest. They are also particularly prevalent in the vicinity of cold ocean currents.

Over the land, on clear nights with little wind, a sharp drop in temperature occurs after sunset as a result of the Earth radiating its heat away into space. The air in contact with the ground is cooled, condensation takes place and fog is formed. Such land-formed fogs are known as *radiation fogs*, and are most common in the winter with its long nights; they are thickest in the latter part of the night and early morning. As the Earth becomes heated during the day such fogs become thinner and often disperse. They frequently affect harbours, especially in smoky industrial areas, and may drift seaward under the influence of offshore winds, thus giving rise to coastal fog. If the sky is cloudy, fogs of this type are improbable, because the clouds act as a blanket and to a large extent prevent the Earth losing heat by radiation; neither do they occur with strong winds, which thoroughly stir the air and so prevent any of it remaining long enough in contact with the cold ground.

As fog can only occur when the air is saturated, or very nearly so, the hygrometer (wet and dry bulb thermometers) provides a useful guide to its probability.

Pressure systems

The relationship between pressure distribution and wind direction has already been explained on page 536. From this relationship it follows that in the northern hemisphere the wind circulates round an area of low pressure in a counter-clockwise direction, and in the southern hemisphere in a clockwise direction. These areas of low pressure are known as *depressions* or *lows*, and they are generally associated with cloudy, unsettled weather and strong winds. Depressions usually move fairly quickly and almost always from a westerly towards an easterly point. In the northern hemisphere the approach of such a system is therefore heralded by the wind backing towards a southerly point. Its approach is also foreshadowed by a falling barometer, an increase and thickening of cloud and, later, by rain.

It also follows from this pressure/wind relationship that the circulation round an area of high pressure is clockwise in the northern hemisphere and counter-clockwise in the southern hemisphere. Such an area of high pressure is known as an *anticyclone* or *high*. Like depressions, anticyclones generally move in an easterly direction; but in the eastern parts of the oceans the movement is usually slow and erratic, and an anticyclone may remain nearly stationary for days at a time: consequently the weather often remains much the same for considerable periods, and then changes slowly. Anticyclonic weather is often fine and sunny though at times overcast and gloomy weather prevails; winds, however, are only light or moderate in strength and rain is unlikely; radiation fog often forms over the land at night and affects harbours and coastal areas, and in winter it may persist throughout the day.

LOCAL FORECASTING

A short-range forecast of changes in the weather can often be made by intelligent observation of wind, cloud and sky and of the movements and readings of the barometer. Local weather lore is also of assistance, though it must be remembered that not even the best-known and most reliable saying about the weather is infallible; no saying based upon the phases of the moon has any meteorological significance whatsoever. It must also be remembered that local weather lore applies to the locality of origin, and cannot be applied indiscriminately elsewhere. The following indications, when taken in conjunction with such other evidence as may be available, should help an isolated observer to forecast the weather for the next few hours in the eastern North Atlantic.

Barometer

The average barometer reading in the south of England is about 1014 millibars, and in the north of Scotland it varies from about 1013 millibars in summer to 1008 millibars in winter; the following table shows the probable weather to be expected for different departures from these normals.

Barometer 5 mb. or more below normal, and steady or falling.	Unsettled
Barometer 5 mb. or more above normal, and steady or rising.	Settled for at least a day, with light or moderate winds

Barometer below 1000 mb. or falling rapidly at 1 mb. or more in an hour.	Strong winds and rain
Barometer rising rapidly.	Fair or fine, usually followed in a day or so by another fall and more unsettled weather
'Long foretold, long last; Short notice, soon past'.	Indicating that a steady fall over a long period foretells a long spell of bad weather, but a rapid fall indicates a short but severe spell
'First rise after low Foretells a stronger blow'.	Indicating that the full force of a gale is often felt after the centre of a depression has passed. Gales with a rising barometer are always squally.

Wind

In the absence of a weather map the relationship between wind direction and weather in Home waters and the north-eastern Atlantic is not well defined, but it is possible very broadly to distinguish the following four main types.

South-westerly winds. These come from the warmer waters of the Atlantic further southward and are cooled at the surface by the progressively decreasing sea temperatures as they travel towards us. Weather is mild and damp, with poor visibility, and skies are nearly or quite overcast with a pall of low cloud. Drizzle is common on windward coasts, and weather is generally unsettled, with the probability of rain. In late spring and early summer sea fog may occur.

North-westerly winds. These bring cold air from higher latitudes, which is warmed at the surface during its passage over progressively warmer water. Weather is cool or cold, with good visibility, and clouds of the cumulus type are formed from which showers fall. In winter the showers may be of snow.

North-easterly winds. These have usually come from Scandinavia or north Russia. Weather is cool in summer and cold in winter. Skies are most often cloudy or overcast, and snow is common in the winter.

South-easterly winds. These have usually come from central Europe, and are cold and dry in winter and warm and dry in summer. Cloud amounts are generally small.

The following sayings originated in the days of sail, long before weather forecasting became a science, but they are well worth remembering; they apply, of course, only to Home waters and the north-eastern part of the Atlantic.

A veering wind—fair weather: a backing wind—foul weather.	A wind backing towards a southerly point is often an early sign of an approaching depression; a veering wind indicates that the *low* is passing away eastward and that improving weather will be expected.

'If the wind is north-east three days without rain, Eight days will pass before south wind again.'	One of the most striking features about weather in these latitudes is the tendency for a given type—good or bad—to persist once it has become established. This tendency is recognised in these sayings.
'When the rain's before the wind, Topsail halliards you must mind; When the wind's before the rain, Hoist your topsails up again.'	With an approaching depression, if there is little wind when the rain starts it will probably blow hard before long; whereas if the gale comes first it will probably have done its worst by the time the rain comes.

Sky

A low sunset—fair weather; a high sunset—rain and/or wind.	A sunset is low when the sun sets on a clear horizon; a sunset is high when it sets behind a bank of cloud well above the horizon. Bad weather usually approaches from westward and is preceded by a bank of cloud which hides the sunset.
Bright yellow sunset	Wind
Pale yellow sunset	Rain
Red sunset	Fair weather

Clouds

Soft-looking, delicate, low clouds	Fine weather, with light or moderate breezes
Hard-edged, oily-looking clouds	Wind
Small, inky-looking clouds	Rain

After fine, clear weather the first signs in the sky of a coming change are usually light streaks, curls, or wisps of distant white cloud, which increase until the sky takes on a milky appearance and the sun and moon become surrounded by haloes. The cloud thickens until the sun and moon are seen only indistinctly through a watery sky, which foretells rain within a few hours. These are infallible signs of an approaching depression, but often they cannot be seen because the sky is covered with lower clouds.

Misty clouds forming or hanging on heights	If they remain, there will be wind and rain; if they rise or disperse, the weather will improve or become fine.

General

When sea birds fly out early and far to seaward	Fair weather and light or moderate winds
When sea birds remain over land or fly inland	Stormy weather

Dew and fog forming inland at night	Fine weather; neither dew nor fog form under an overcast sky, or when there is much wind.

CLIMATE

Climate may be defined as being the average condition of the atmosphere taken over a long period, and is largely dependent on the average condition of the wind, weather and temperature; weather, on the other hand, comprises the state of these elements at any given time. In temperate and high latitudes variations from the average are large, and consequently average conditions are not a good guide to the conditions likely to be experienced on any given day. In the tropics, however, such variations are much smaller and averages give a truer picture of the actual weather conditions likely to be experienced.

Climate is governed largely by the average distribution of barometric pressure over the surface of the Earth, and by the greater amount of heat received from the sun in low latitudes than in high latitudes. Fig. 19–1 shows diagrammatically what would be the normal distribution of pressure over the Earth were it entirely covered by water, together with the resulting winds and the names long given by seamen to the various regions. This idealised distribution is called the 'planetary' system.

The zones shown in fig. 19–1 oscillate according to the seasons; they reach their most northerly position in about July or August, and their most southerly in January or February. The amount of oscillation generally averages only some 5 degrees of latitude.

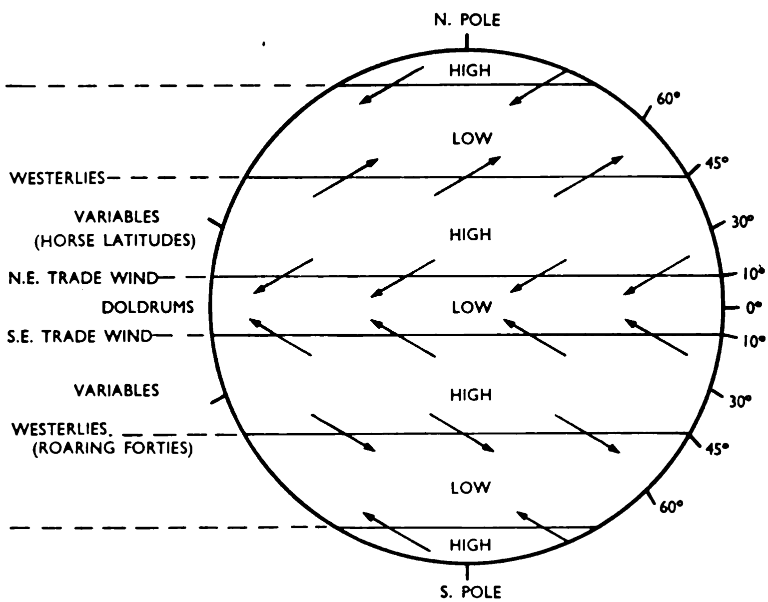


FIG. 19–1. Climate zones

Effects of the distribution of land and sea

The effect of large land masses is considerably to modify the 'planetary' distribution of pressure and wind shown in fig. 19–1. The belts of high pressure in latitudes about 30°N and S are split up into separate cells of high pressure (or anticyclones) situated over the eastern part of each ocean. The belt of low pressure in latitude about 60°N is likewise modified into separate areas of low pressure situated in the vicinity of Iceland and the Aleutian islands.

In the southern hemisphere there is little land in the area covered by this low-pressure belt, and consequently it extends almost uniformly around the Earth.

Superimposed on the above modifications of the general planetary system are the seasonal changes in pressure distribution caused by the summer and winter temperatures of great land masses. It is these changes that establish seasonal winds such as monsoons, which are described below.

OCEANIC WINDS

The general distribution of oceanic winds in winter and summer is shown in figs. 19–2 and 19–3, and the following remarks amplify these wind charts.

Doldrums

That part of the ocean lying in the equatorial trough of low pressure situated between the Trade winds of the two hemispheres is known as 'the Doldrums'. The characteristic features of this zone are calms and light variable winds alternating with squalls, heavy rain and thunderstorms. Apart from these short-lived squalls and tropical storms (which are described below), gales do not occur in this zone.

Trade winds

The main features of the North-east and South-east Trades is their steadiness and persistence. They blow permanently throughout the year and vary but little in direction. Their average strength is about force 3–4 Beaufort scale, though at times they may freshen to force 5 or 6, and at others lull to force 1. Apart from occasional squalls, winds of gale force are rare, and when they occur are usually associated with tropical storms. It should be noted that the Trade winds do not blow in the northern part of the Indian Ocean, or the western part of the North Pacific, in which areas their place is taken by the monsoons, which are described below.

Variables

In each hemisphere, between the poleward limit of the Trades and the low latitude limit of the Westerlies, there exists a belt of mainly light or moderate winds. These winds are known as the 'Variables' and the areas in which they occur as the 'Horse Latitudes'. These areas are indicated in figs. 19–2 and 19–3, centred approximately in latitude 30°. Towards the equator they merge gradually into the Trades, while polewards they merge into the prevailing Westerlies of higher latitudes.

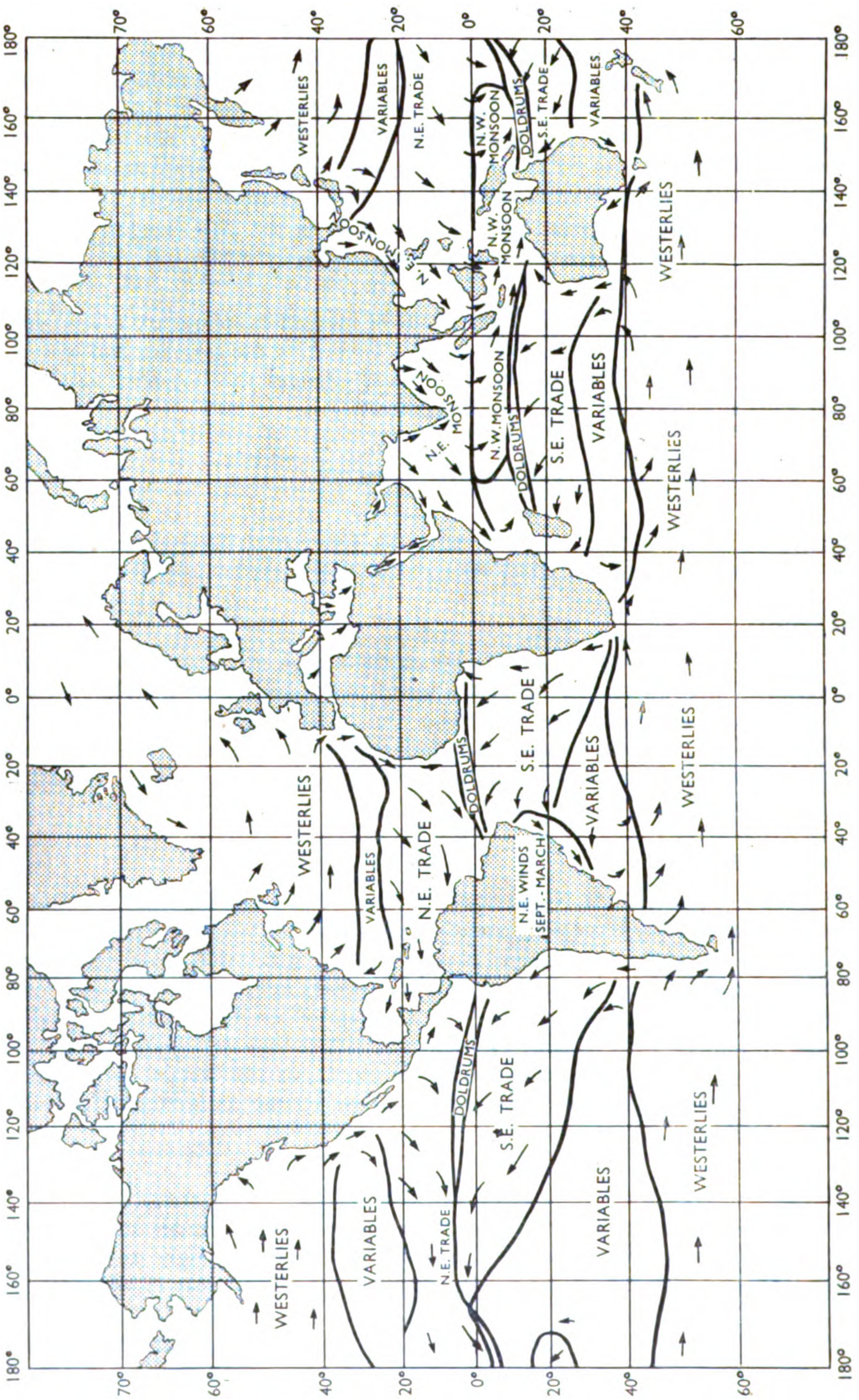


FIG. 19-2. Wind chart for January, February and March

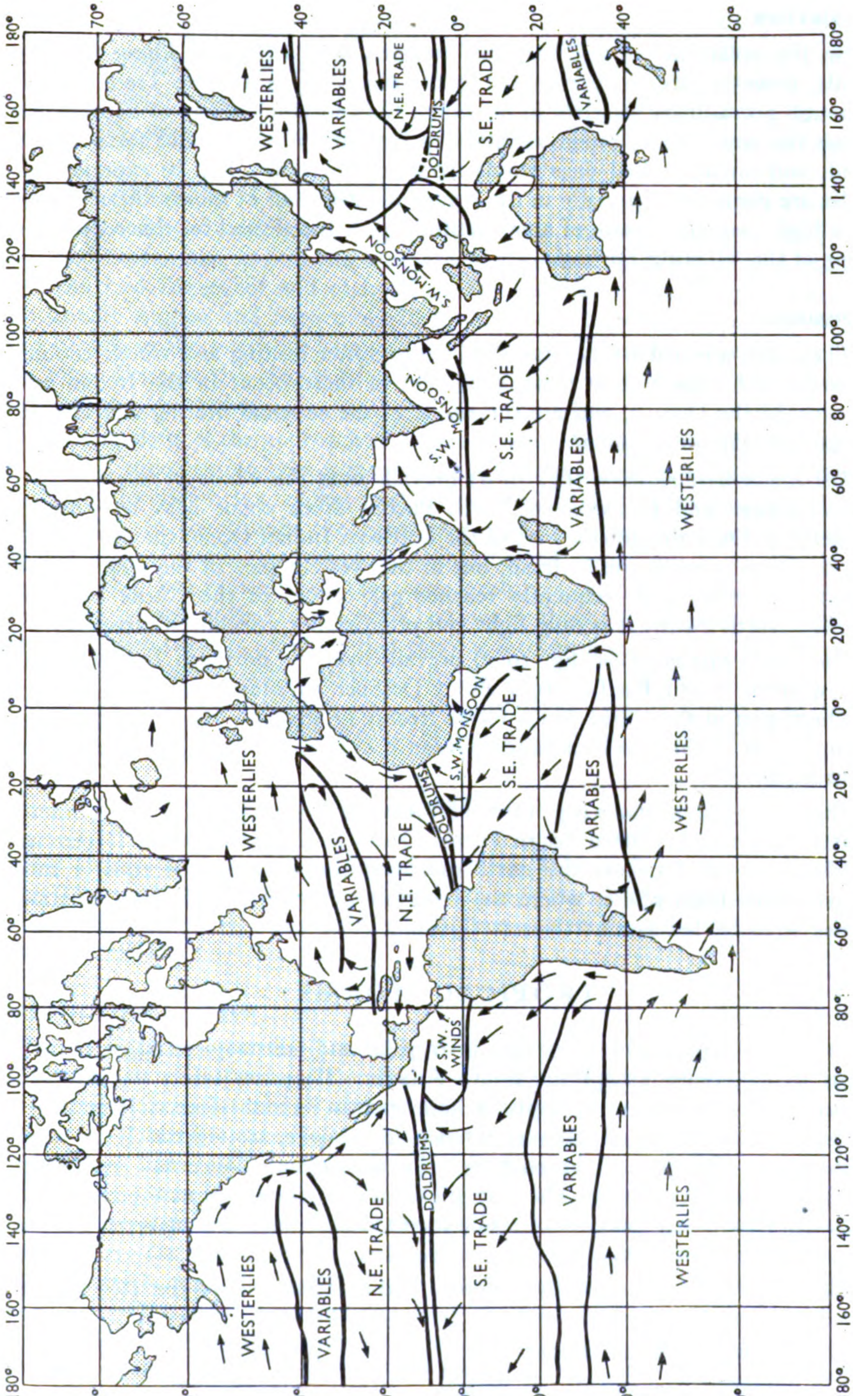


FIG. 19–3. Wind chart for July, August and September

Westerlies

On the polar side of the Variables westerly winds prevail. These westerly winds, however, are not permanent in the same way as are the Trade winds; although prevailingly westerly in direction, the constant passage of depressions across the zone causes much variation in both the direction and force of the wind, and on individual days winds from any direction may be experienced. Gales are common, especially in the winter months, and in the southern oceans their high frequency south of about latitude 40°S has earned for this region the name of the 'Roaring Forties'.

Monsoons

These are seasonal winds caused by the summer heating and winter cooling of large land masses. The most important of these occur in the Indian and western Pacific Oceans, and are the result of the seasonal heating and cooling of the vast Asiatic continent.

The South-west monsoon (fig. 19–3) prevails over the whole of the northern Indian Ocean and the western North Pacific, from about May or June to September. Over the greater part of the northern Indian Ocean the strength of the monsoon is moderate or fresh, but in the western part of the Arabian Sea it blows strongly and frequently reaches gale force; in the China Sea and western North Pacific it is only light and often rather variable in direction.

The North-east monsoon (fig. 19–2) prevails over the northern Indian Ocean and western North Pacific, from about October to March or April. In the northern part of the China Sea it blows freshly or strongly, reaching gale force at times, but in the northern Indian Ocean it is usually only light or moderate in strength.

The North-west monsoon (fig. 19–2) blows in the northern part of the southern Indian Ocean and western South Pacific Ocean from November or December to March. It results from the north-east monsoon crossing the equator into the southern hemisphere, where the reversed effect of the Earth's rotation causes it to be felt as a north-westerly wind.

TROPICAL STORMS

These storms are a serious menace in tropical and sub-tropical latitudes, and occur in all oceans except the South Atlantic. They are rarely encountered within about 8 degrees of the equator, and never in its immediate vicinity. They consist of relatively small but very intense depressions, around which the wind circulates in the normal direction for the hemisphere concerned and often reaches hurricane strength. The very high winds experienced in the storm are a cause of extremely heavy seas, while torrential rain and driving spray reduce visibility to almost nothing.

These storms are known by different names according to the part of the world in which they occur:

Western North Atlantic	hurricanes
Arabian Sea and Bay of Bengal	cyclones
South Indian Ocean	cyclones

North-west Australia and vicinity	cyclones
Western North Pacific	typhoons
Eastern North Pacific	hurricanes
Western South Pacific	hurricanes.

Seasons, and signs of approach

In the northern hemisphere nearly all tropical storms occur between June and mid-November, and in the southern hemisphere they are unlikely except between mid-December and early May. The months of maximum frequency are usually August and September in the northern hemisphere and February and March in the southern hemisphere. In the Arabian Sea, however, storms are most likely at the change of the monsoon, i.e. in May and June, and in October and November.

Warning signs of the approach of a tropical storm are given in *The Mariner's Handbook*, and mention here is made only of the necessity for keeping a careful watch on the barometer reading in the areas, and during the seasons, in which they occur. In the tropics the barometer reading varies little, apart from a regular diurnal oscillation which is visible on the barograph trace. Provided that the ship has remained in the same locality, a reading of 3 mb. or more below the average at that time for the last two or three days should be regarded with suspicion, as it is probable that there is a tropical storm within 300 miles or so. Ships encountering tropical storms should immediately inform the nearest meteorological centre and thereafter send regular reports, so that warnings may be transmitted to other shipping and to port authorities.

LOCAL WINDS

In the vicinity of the coast, and thus in harbours, the wind experienced is often very different from that blowing over the adjacent ocean. It is not possible here to go fully into these many local effects, but two of the most important are described below.

Sea and land breezes

These regularly alternating winds are a conspicuous feature of nearly all tropical coasts and islands (other than very small islands), and they occur also in temperate latitudes in fine settled weather in the summer. They are caused by the daily, unequal heating and cooling of land and water by radiation. By day the land and the air over it rapidly acquire heat from the sun's rays, whereas the sea temperature remains virtually constant; the heated air over the land therefore expands and rises, and the cooler air over the sea flows in to take its place and results in an onshore wind known as the 'sea breeze'. This sea breeze generally starts at about 1100 local time, reaches its maximum strength (usually about force 3) at about 1400, and dies away at sunset. By night the rapid cooling of the land, and consequently of the air in contact with it, results in the cooled, dense air flowing offshore as the 'land breeze' to take the place of the then warmer air rising from the sea. In most places the land breeze is much weaker and less evident than the sea breeze, because by day the difference in tem-

perature of the land and sea is considerable, but at night it is very little; it usually starts during the first watch and blows until about sunrise.

Eddies and squalls

In confined harbours backed by high ground, or close to mountainous coasts, winds are often fluky and conflicting. Offshore winds in such localities, if at all strong, are likely to be accompanied by severe squalls which are dangerous to boats and small craft and may cause ships to drag their anchors. Their likelihood should be borne in mind when taking shelter under the lee of high land, and especially off the entrances to narrow valleys, where they often occur.

CLIMATIC ZONES

The climate of any place depends upon a large number of inter-related factors. These include not only the most obvious one of latitude, but also the direction of the prevailing winds and whether they reach the area under consideration after a long passage over the sea or the land, and the degrees of exposure to, or shelter from, such winds due to local topography. Considerable variations of climate may thus be found even between closely adjacent areas, and no very simple picture of world climate can therefore be drawn. It is possible, however, to distinguish very broadly the following climatic zones, though the limits of latitude given must be regarded as very approximate and it must be remembered that each zone merges gradually into that adjacent to it.

Equatorial zone (within 3° or 4° of the equator). In this zone seasons are practically non-existent. Temperature is uniformly high throughout the year, the rainfall (usually in the form of heavy showers) is abundant in all months. Winds, apart from thundery squalls, are light and variable, and land and sea breezes are prevalent on the coast. Fog is almost unknown except in the early morning over low-lying, damp places ashore.

Tropical zone (latitude 4°–15° North and South). The main feature of this zone is the alternation of the wet season, which occurs in the summer of the hemisphere concerned, with the dry season which occurs in the winter and during which little or no rain falls and there is much sunshine. Over Asia this zone extends further north and includes the whole of India and Burma. Temperature is generally highest immediately before the start of the rainy season.

Dry zone (latitude 15°–30° North and South). This zone is really only dry on the eastern side of the oceans it embraces. It is nevertheless in this belt that most of the major deserts of the world are found, i.e. the Sahara and Kalahari Deserts in North and South Africa, the Arabian Desert in Asia, the Great Australian Desert, and the dry zones of the western parts of North and South America. On the eastern side of the oceans, too, this zone has much sunshine and very little rainfall. Here the Trade winds usually prevail. Temperatures are comparatively low for the latitude owing to cold ocean currents flowing along the coast, and poor visibility occurs fairly frequently owing to the coldness of these currents, and sometimes to sand and dust being carried seaward by the prevailing offshore wind.

In similar latitudes on the western side of the ocean, rain is experienced in

all months and is heaviest in the summer. Fog is rare, and temperatures are fairly high except for three or four months during the winter.

Sub-tropical zone (latitude 30°–40° North and South). On the eastern side of the oceans (e.g. in the Mediterranean and off Capetown, California and S.W. Australia) the summer is hot and dry and the winter is mild and rather rainy owing to moving depressions, which also bring strong winds and gales. Even in winter, however, there are often fine, sunny periods.

On the western side of the North Atlantic and North Pacific Oceans this belt is, for its latitude, often very cold in winter and very warm in summer; the winter cold is largely due to the prevailing offshore north-westerly or northerly winds, and the summer heat to southerly onshore winds. In winter gales are frequent in the central and western parts of these oceans, but in summer, conditions are usually quiet. In the southern hemisphere the winter in this zone is never particularly cold, owing to the absence of any sufficiently large continental land mass.

Temperate zone (latitude 40°–65° North and South). The most conspicuous feature of the weather in this zone is its great variability; nearly all the weather elements are liable to show sharp contrasts from one day to another. Owing to depressions constantly travelling through this region, fine weather is seldom prolonged and gales are frequent, especially in winter.

In winter, on the western side of the North Atlantic and North Pacific Oceans it is very cold, with prevailingly north-westerly winds; but on the eastern side the prevailing south-westerly winds maintain mild weather, which is broken only occasionally by an outburst of cold weather when the wind temporarily becomes easterly or northerly in origin.

In summer on the western side of these oceans, the prevalence of southerly winds blowing over the cold currents which flow there results in a very high frequency of sea fog. Elsewhere in the open seas of this zone sea fog is most likely in the late spring and early summer, though in harbour and close to the coast the incidence of fog formed by land radiation makes fog most frequent in winter months.

It is in this zone particularly that climatic averages are apt to be most misleading, and day-to-day forecasting is the only method of obtaining satisfactory advice on the future weather.

WEATHER REPORTS AND WEATHER FORECASTS

The basis of weather forecasting is the observation and reporting of actual weather conditions at fixed hours (normally 0001, 0600, 1200 and 1800 G.M.T.) at a large number of positions in all parts of the world. These actual weather reports ('synoptic data') are sent with all possible speed to collection centres, where they are used to compile weather maps, which are then analysed and forecasts deduced. As so much of the Earth's surface is covered by sea, observations from ships at sea are particularly valuable—the more so, in fact, since they are more representative than land station observations, which may be distorted by topographical features. It cannot be emphasised too strongly therefore how important it is for ships to make accurate, prompt and reliable reports at the times laid down by international agreement. The details of how

to code up observations into a weather report are to be found in the *Admiralty List of Radio Signals*, Volume III. Instructions for their transmissions will be found in *R.N. Signal Orders* (S1 of each year).

Twice a day Fleet Weather Forecast Messages are broadcast from various centres for the benefit of H.M. ships. Details of these messages will also be found in the above references. In general, they contain summaries of gale warnings in force and sea area forecasts. Gale warnings are also broadcast immediately they are issued on all main services.

METEOROLOGICAL INSTRUMENTS

Various meteorological instruments are provided in H.M. ships and are described below. Apart from the interpretations which a good seaman can place on the readings of these instruments, they are also supplied to ensure that ships are able to make their weather reports. To ensure that the instruments give accurate readings, regular checks are essential, especially in the case of the aneroid barometer, which should always be compared with a standard barometer ashore before leaving harbour.

Mercurial barometer

Basically this instrument (fig. 19-4) consists of a glass tube closed at one end and filled with mercury. The tube is inverted and its open end placed below the level of the surface of the mercury in a small cistern; the mercury in the tube then descends until the weight of the column is balanced by the pressure of the atmosphere on the mercury in the cistern, thus affording a measure of that pressure. By means of a scale whose zero is level with the surface of the mercury in the cistern the exact height of the column can be read.

Great care should be exercised in handling a mercurial barometer. The tube is easily broken if the instrument is suddenly turned from its normal vertical position with the cistern down, since the vacuum above the mercury offers no resistance to this heavy liquid, which drops as though it were a solid metal rod.

It is advisable to unship the barometer before carrying out weapon firing, unless it is kept low down in the ship and well protected from shock. When unshipped the barometer should be tilted slowly to an angle of about 45° and be held in this position until the mercury has crept up the tube and completely filled it. It should then be inverted very slowly and stowed with the cistern end uppermost.

The Barometer Correction Slide. Mercury barometers are calibrated to indicate true atmospheric pressure at sea level at a selected 'standard' temperature in latitude 45°. In practice these conditions rarely apply and the actual reading of the barometer must be corrected for height above sea level, latitude and temperature in order to obtain the true atmospheric pressure at 'mean sea level'. These corrections are extracted in one operation by means of the barometer correction slide (figs. 19-4 & 5), which is clamped to the lower half of the barometer.

The slide incorporates a thermometer, scales of latitude and height above sea level, and also a scale for instrumental index error which is set, once for all, during calibration of the barometer. The sliding scale is usually set by the

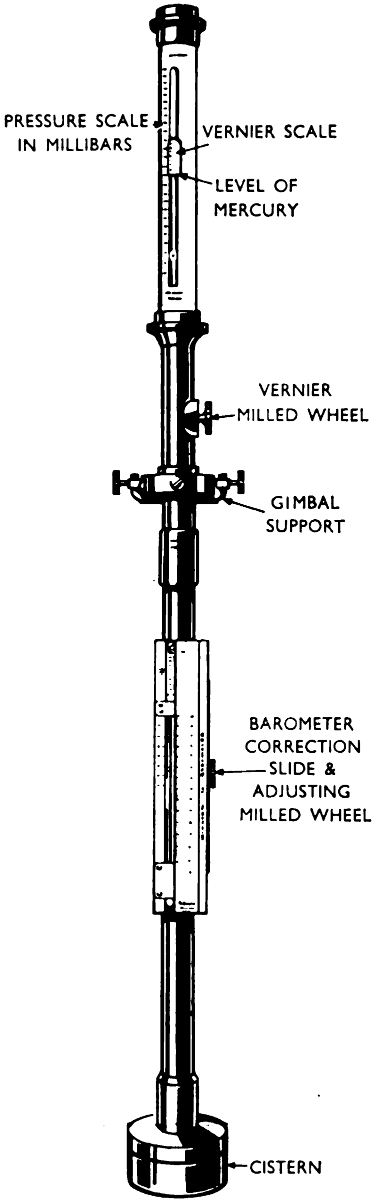


FIG. 19–4. A mercurial barometer

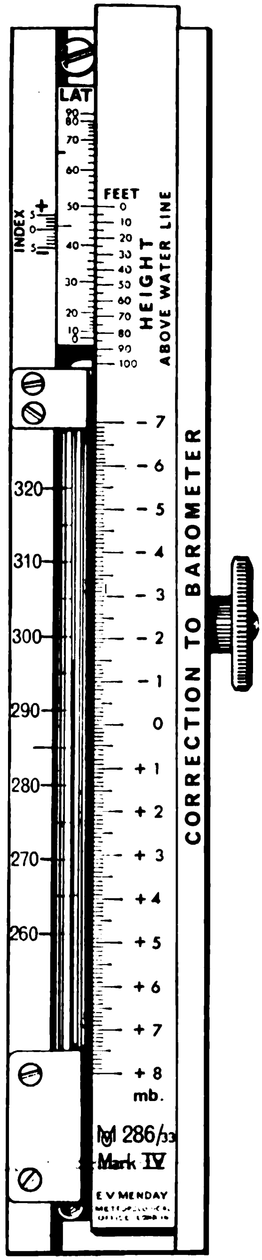


FIG. 19–5. Barometer correction slide

Meteorological Officer, or the Chief Quartermaster when no Meteorological Officer is borne, for the height of the barometer above sea level and the ship's latitude, and it should be altered only when the latitude of the ship is appreciably changed.

How to read the barometer. The correction from the slide *must be obtained first,* because the proximity of the observer may affect the thermometer and cause an erroneous temperature correction. The necessary (total) correction is read off the millibar scale of the slide in units and tenths (plus or minus) against the height of the thermometer (in fig. 19–5 it is — 1·5 millibars) and is then added to (if plus) or subtracted from (if minus) the actual reading of the barometer.

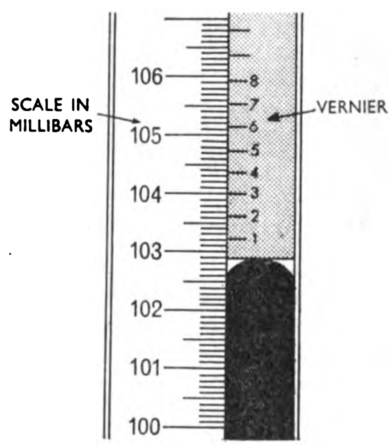


FIG. 19–6. Reading the height of the mercury

The barometer should now be read in the following manner: Turn the milled wheel of the *vernier* scale until the lower edge of the vernier and the corresponding edge of the slide at the back of the instrument are exactly level with the top of the domed surface of the mercury. Then:

1. Note the scale line next below the level of the top of the mercury column, as shown by the left-hand lower edge of the vernier (in fig. 19–6 this is 1028).
2. Look at the vernier and note which of its lines is exactly in line with a line on the scale (in fig. 19–6 this is the line marked 3, and represents 0·3 of a millibar).
3. Add the two together to obtain the uncorrected reading of the barometer (in the example given in fig. 19–6 this is 1028 + 0·3 = 1028·3 millibars).

The correction previously obtained from the slide should now be applied to this uncorrected reading to obtain the true reading of the barometer. (In the examples given in figs. 19–5 and 19–6 the true reading is thus 1028·3 — 1·5 = 1026·8 millibars.)

Aneroid barometer

This depends for its indications on the very slight movements of the top of a

disc-shaped metal box. The box is made of very thin corrugated metal and is partially exhausted of air, which makes it very susceptible to the slightest change in external pressure. The slightest movement of the top of the box is transmitted by a system of magnifying levers to a pointer, which moves over a graduated dial.

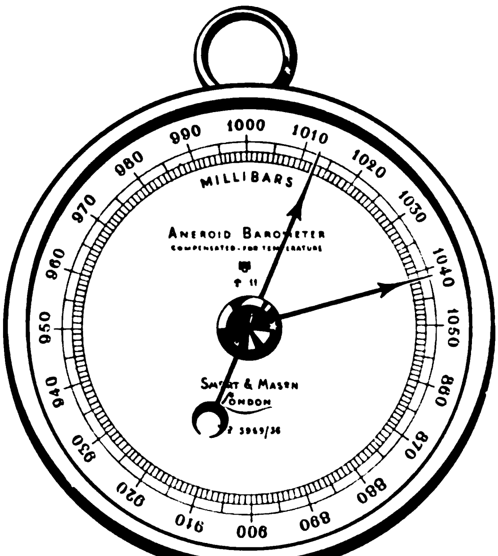


FIG. 19–7. An aneroid barometer

Aneroid barometers are liable to get out of adjustment, and the instrument should therefore be checked frequently with a mercurial barometer. If the instrument is shifted to a new position at a different height it will require readjusting. It should be tapped very gently before it is read.

Precision aneroid barometer

A precision aneroid barometer with a greater accuracy and reliability is being used increasingly in ships for the measurement of atmospheric pressure, instead of the fragile mercurial barometer. Working on the aneroid principle described above, this instrument (when correctly set) displays the atmospheric pressure directly in millibars and tenths on counters (the thousands figure may be omitted). This numerical display is adjustable by means of a milled knob at the end, and the correct pressure is recorded when a thread of light in a cathode ray indicator is just on the point of breaking. To read the instrument:

1. Press the black switch button.
2. If the thread of light in the cathode ray indicator appears in two discontinuous portions, turn the milled knob so that the pressure reading decreases until the thread of light appears as one continuous line.
3. Gently turn the milled knob, increasing the pressure reading until the thread of light *just* breaks.

4. Read the pressure from the numerical display. Remember that for logging purposes a decimal point must be put in between the last two figures.

To obtain mean sea-level pressure, a fixed correction for the height of the instrument above sea level must be added. This amounts to 1 millibar per 28 feet or a proportion thereof, and a permanent note of it should preferably be displayed in the vicinity of the instrument.

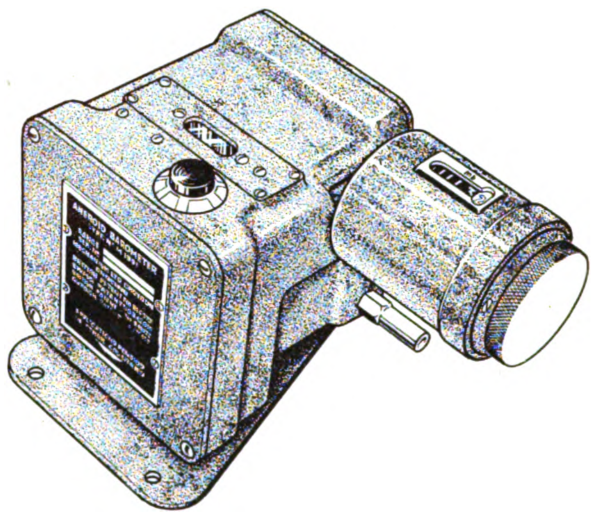


FIG. 19–8. A precision aneroid

Great care should be taken when handling this precision instrument. It should be installed in a horizontal position, firmly fixed to a flat, level surface so that it can be read with ease but is protected from knocking or jolting.

Regular checks, at least once every three months, of the accuracy of the instrument should be made against a reliable barometer ashore. If a series of comparisons over a range of pressure values consistently shows a difference, *no adjustment should be made to the barometer*, but the appropriate correction should be noted and applied (in combination with the correction to mean sea level) when reading the instrument. On no account should the instrument be opened up except to replace batteries, for which instructions are supplied with the instrument.

Barograph

This is a type of aneroid in which the pointer is replaced by a pen which records on a rotating clockwork drum the movements of a corrugated cylinder known as the *bellows* (fig. 19–9). The drum makes one revolution in seven days, and the charts provided are graduated to indicate the day of the week and the time, as well as the atmospheric pressure in millibars. This instrument is useful in that it provides a continuous record of atmospheric pressure; it also enables an observer to detect casual errors in the reading of the mercurial barometer, and

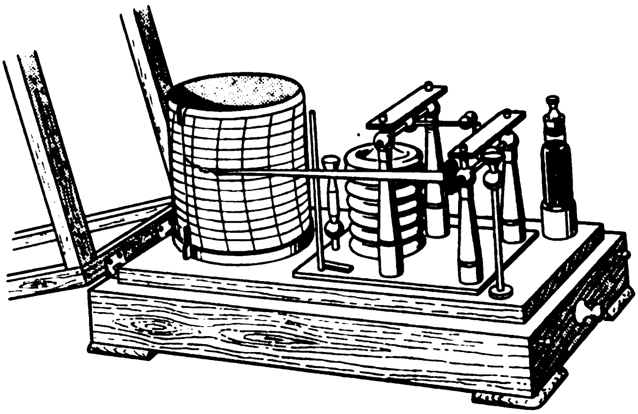


FIG. 19–9. A barograph

registers minor fluctuations of pressure which would seldom be noticeable in the action of the mercurial barometer.

The barograph should be placed in a position where it is least likely to be affected by vibration, concussion and gusty draughts of air, and should be secured in an athwartships position so that the pen does not leave the paper when the ship is rolling.

Thermometers

For meteorological purposes the temperatures of the air and the sea surface are required. The air temperature is obtained from the dry bulb thermometer of the hygrometer, which is described below.

For measuring sea-surface temperature a similar thermometer is used, but fitted with a *sea protector* (fig. 19–10) which forms a metal cup or reservoir for retaining a small quantity of sea water around the bulb while the temperature is being read. A sample of the *surface* water is obtained in a canvas bucket of diameter not less than five inches, from over the ship's side before all discharge pipes. The thermometer should be held for a minute in the sample and then removed; the water in the reservoir is poured back into the sample, which is then thrown over the side. The object of this is to bring the thermometer and the bucket approximately to the temperature of the sea surface. A second sample of sea water is then obtained and the thermometer moved up and down in the water until the temperature becomes steady; a reading should be obtained within 30 seconds of the immersion of the thermometer.

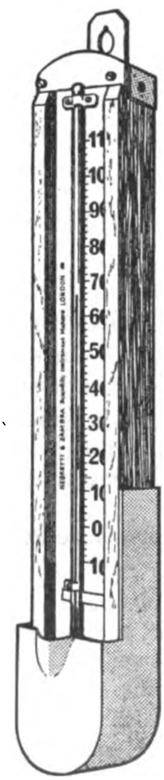


FIG. 19–10. A sea thermometer

An improved type of bucket (fig. 19–11), made of canvas-reinforced rubber and incorporating a sea thermometer protected by a sheath, has been designed for use on board ships under way and is in use in some men-of-war. Having been firmly attached to a suitable part of the ship's superstructure by a length of line, the bucket containing the thermometer is cast overboard and towed through the water for about one minute. When the bucket is brought inboard

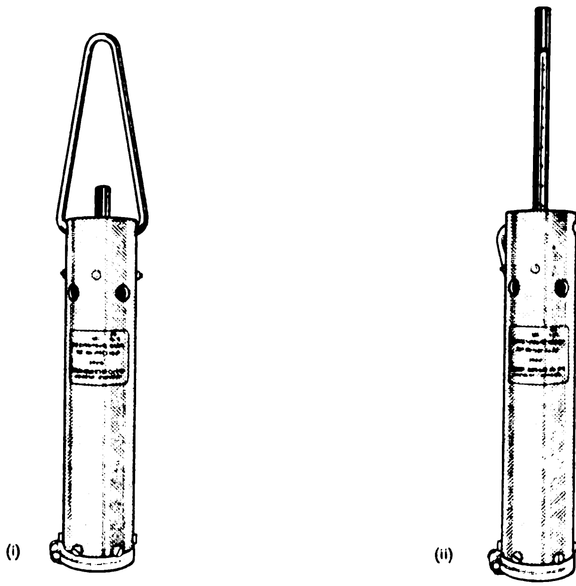


FIG. 19–11. (i) Rubber sea temperature bucket; (ii) the same with sheath withdrawn

the sheath should be partially withdrawn to facilitate reading, which should be carried out as quickly as possible to avoid errors arising from heating or cooling of the apparatus by the surrounding air.

As it is the surface temperature that is required, temperatures obtained from a thermometer in an engine-room circulator intake should not be used, unless the weather is so bad that the normal methods cannot be used.

Hygrometer

This instrument (fig. 19–12) is for measuring the humidity of the air. It consists of two thermometers, called the *wet* and *dry bulbs*, kept in a ventilated or 'louvred' screen. One thermometer registers the temperature of the air; the other has its bulb surrounded by a piece of muslin, which is kept moist by a wick connecting it with a small pot of distilled water. Evaporation from the muslin lowers the temperature of the wet bulb, which consequently reads lower than the dry. The drier the air the greater is the rate of evaporation, and the greater will be the difference between the wet and dry bulb readings; consequently the readings of the wet and dry bulb thermometers provide a measure

of the humidity of the air. In arctic conditions, when the air temperature is persistently below freezing, it is advisable to remove the wick and pot altogether and to wet the bulb directly with ice-cold water, preferably some 15 minutes before taking readings, the film of ice thus formed being renewed as necessary.

The screen must not be bolted to a bulkhead; it should be moved about as necessary to expose it on the windward side to air coming in over the ship's side, clear of the effects of local heating. The water pot must be kept topped up with distilled water, and the dry bulb must be clean and free from salt. The muslin and wick should be changed and the pot be washed out and refilled with distilled water at frequent intervals and always after heavy weather.

If the wet bulb becomes frozen its readings are still valid provided it is coated with ice. Ultimately, however, the coating of ice will entirely evaporate, and so the muslin must be wetted by means of a small brush or feather; a new film of ice will then form, and the wet bulb should be read when its reading has become steady.

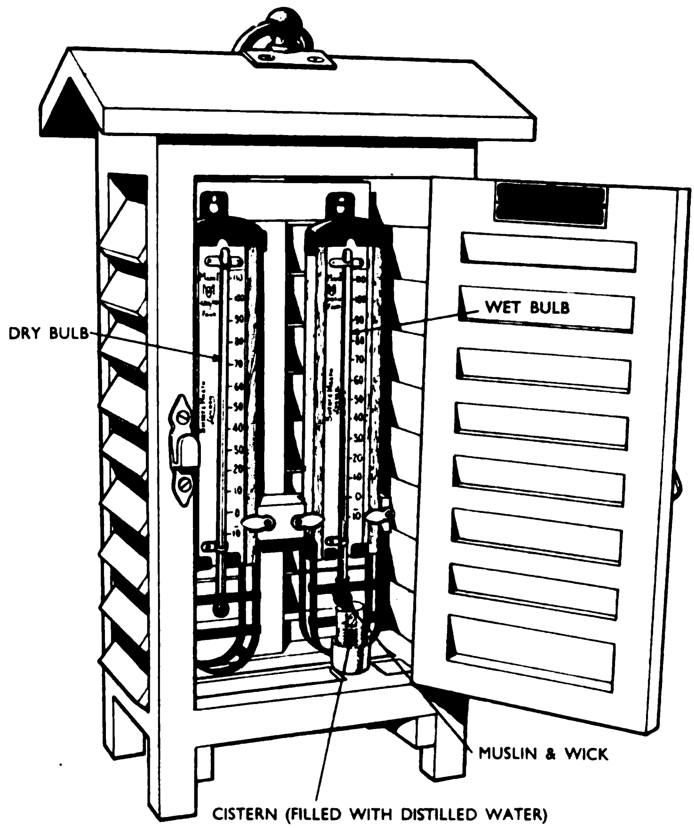
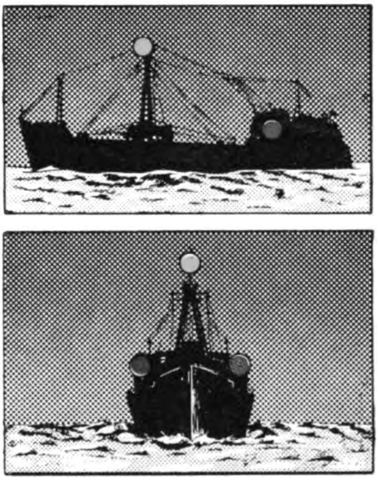


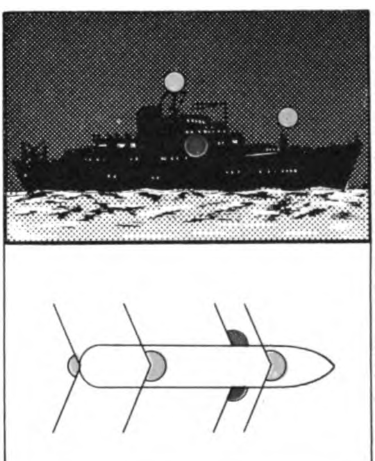
FIG. 19–12. A hygrometer in a shipboard screen



Power-driven vessel, less than 150 feet in length, under way at night

Rule 2 (a) (i). A power-driven vessel under way at night, *less than 150 feet in length*, carries one white steaming light and port and starboard bow lights.

Rule 10. In addition to the above lights, this Rule prescribes a white " overtaking " light for all vessels under way (not visible in the illustrations).



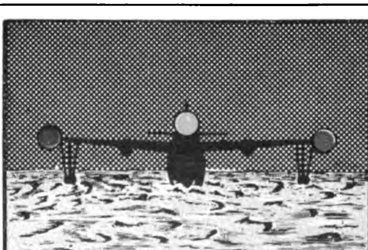
Power-driven vessel, 150 feet or more in length, under way at night

Rule 2 (a) (ii). A power-driven vessel under way at night, *over 150 feet in length*, carries two white steaming lights and port and starboard bow lights.

Rule 10. In addition to the above lights, this Rule prescribes a white " overtaking " light for all vessels under way.

Rule 15. *In low visibility, day or night, power-driven vessels under way sound the following signals (on whistle or siren) at intervals of not more than two minutes:*

if making way—one long blast;
if stopped—two long blasts.



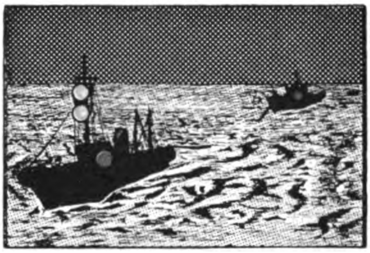
Seaplane taxi-ing at night

Rule 2 (b). A seaplane under way on the water at night carries one steaming light and port and starboard bow lights on the wing tips.

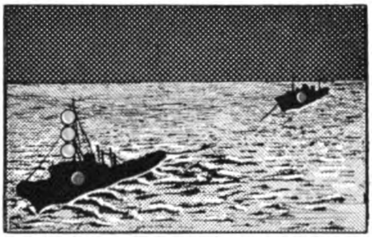
Rule 10. Prescribes in addition an " overtaking " light.

The arcs of visibility differ slightly from those of power-driven vessels.

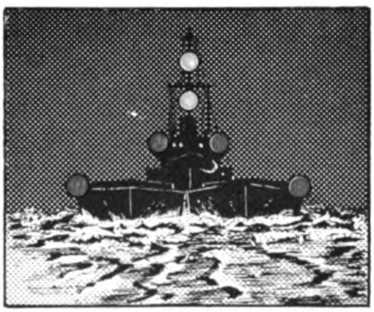
Rule 15. *In low visibility a seaplane on the water is not obliged to make the sound signals of other vessels or craft, but if she does not, she shall make some other efficient sound signal at intervals of not more than one minute.*

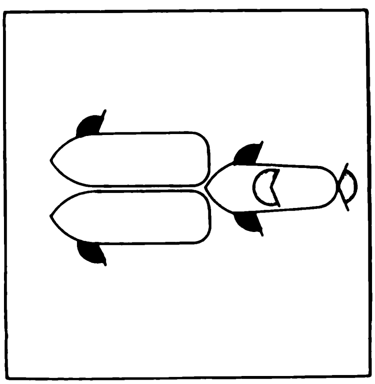


Vessel of under 150 feet towing another at night: length of tow is less than 600 feet



Vessel of over 150 feet towing another at night: length of tow is more than 600 feet





Vessel pushing two other vessels at night

Rule 3. A power-driven vessel towing or pushing another vessel or seaplane carries her bow lights, overtaking light and steaming light.

If the length of tow is *less than 600 feet* an additional steaming light is carried above or below the white light of Rule 2 (a) (i).

If the length of tow is *more than 600 feet* a third steaming light is carried above or below the white light of Rule 2 (a) (i).

The overtaking light may be replaced by a small white light, not visible before the beam, for the tow to steer by.

By day a power-driven vessel towing, if the length of tow exceeds 600 feet, carries a black diamond shape.

Rule 5. The vessel being towed carries bow lights and an overtaking light. If more than one vessel is being towed, all but the last vessel in tow may carry, instead of the overtaking light, a small white light not visible before the beam.

By day the vessel being towed, if the length of tow exceeds 600 feet, carries a black diamond shape.

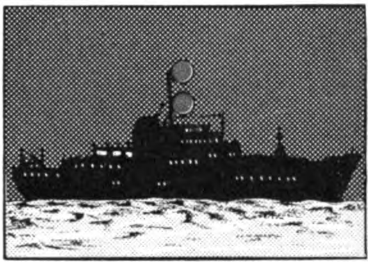
A vessel being pushed carries bow lights at the forward end. Any number of vessels pushed ahead in a group are lighted as one vessel.

Rule 15. *In low visibility, day or night, a power-driven vessel towing sounds the following signal on her siren or whistle at intervals of not more than one minute:*

one long blast followed by two short blasts.

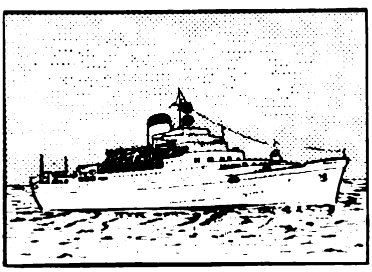
A vessel towed (or, if more than one vessel is towed, only the last vessel in tow) sounds, if manned, on the whistle or foghorn immediately after the towing vessel:

one long blast followed by three short blasts.



Vessel not under command
and stopped, at night

Vessel not under command
but making way, at night



Vessel not under command, by day

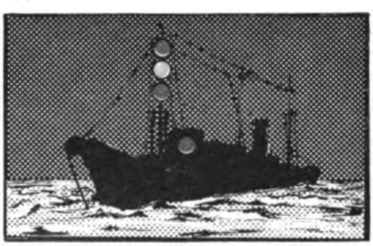
Rule 4. A vessel under way at night, but not under command and stopped, hoists two all-round red lights, one above the other, visible two miles and switches off all other navigation lights.

If she is making way through the water she shows bow lights and overtaking light.

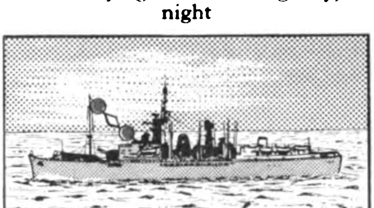
By day a vessel not under command hoists two black balls.

Rule 15. *In low visibility, day or night, a vessel not under command sounds, at intervals of not more than one minute:*

one long blast followed by two short blasts.



A cable-laying vessel making way, at
night



A vessel engaged in
replenishment, by day

Rule 4. A vessel engaged in laying or picking up cable or a navigation mark, surveying or underwater operations, or a vessel engaged in replenishment at sea or in the launching or recovery of aircraft carries, in lieu of her steaming lights, two all-round red lights with an all-round white light between them, each visible at least two miles.

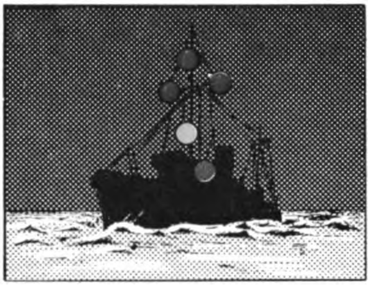
If she is stopped she does not show her bow lights or overtaking light.

By day she hoists two round red shapes with a white diamond shape between them.

These lights and shapes indicate that she is unable to get out of the way of approaching vessels.

Rule 15. *In low visibility, day or night, she sounds, at intervals of not more than one minute:*

one long blast followed by two short blasts.



Minesweeper dangerous to pass close on either side

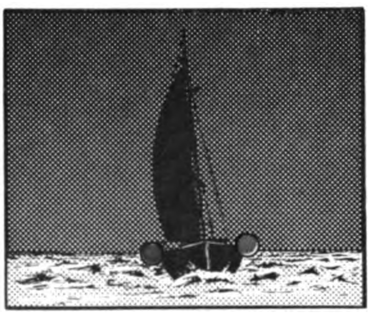
Rule 4. A vessel engaged in minesweeping operations at night carries a green light, visible two miles, at the fore truck and at the end or ends of the fore yard on the side or sides on which danger exists, in addition to her normal steaming, bow and overtaking lights.

By day she carries black balls in the same positions as the green lights.

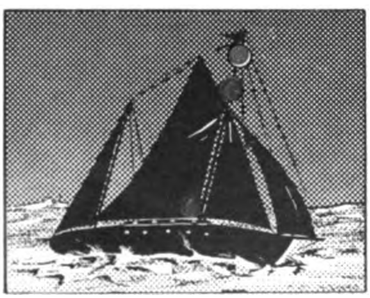
It is dangerous for other ships to approach closer than 3000 feet astern of the minesweeper or 1500 feet on the side or sides on which danger exists.

Rule 15. *In low visibility, day or night, when minesweeping, a vessel sounds, at intervals of not more than one minute:*

one long blast followed by two short blasts.



Sailing vessel under way at night, bows on



Sailing vessel under way at night, showing optional fore masthead lights

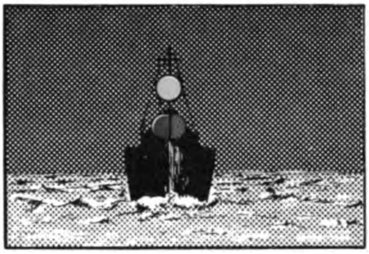
Rule 5. A sailing vessel under way at night carries bow lights.

Rule 10. She also carries an overtaking light.

Rule 5. In addition she may carry on the top of the foremast a red light above a green light, visible two miles and showing from ahead to two points abaft the beam.

Rule 15. *In low visibility, day or night, sailing vessels under way sound the following signals at intervals of not more than one minute:*

one blast—vessel on the starboard tack;
two blasts—vessel on the port tack;
three blasts—vessel running with the wind abaft the beam.



Power-driven vessel of less than 65 feet, at night (using combined lantern)

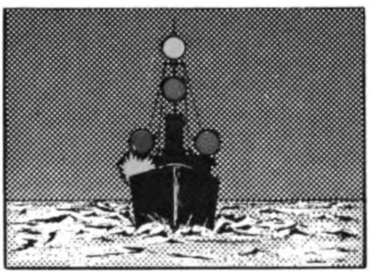
Rule 7. Power-driven vessels of less than 65 feet in length carry one steaming light, bow lights and overtaking light (Rule 10). The bow lights may be combined in one lantern.

When towing or pushing another vessel, they carry an additional steaming light above or below the other steaming light; the overtaking light may be replaced by a small white light when towing.

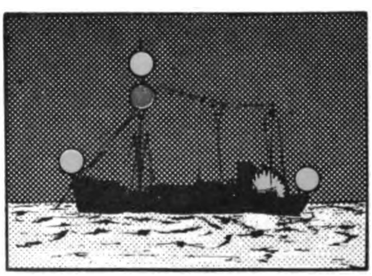
Rule 15. *A power-driven vessel of 40 feet or more in length shall be provided with an efficient whistle.*

In low visibility the sound signals are the same as for larger power-driven vessels.

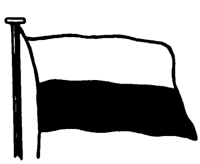
Rule 7. Vessels of less than 40 feet, under oars or sails, shall, if they do not carry bow lights, carry a combined lantern, either fixed or displayed in time to prevent collision.



Power-driven pilot-vessel on duty and making way, at night



Power-driven pilot-vessel on duty at anchor



Pilot-vessel flag *

Rule 8. A power-driven pilot-vessel on duty and under way carries bow lights, overtaking light and, at the masthead, a white all-round light above a red all-round light, both visible three miles.

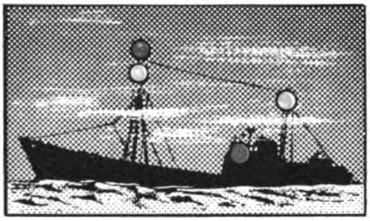
She shows one or more flare-ups at intervals not exceeding 10 minutes or an intermittent white light visible all round.

A sailing pilot-vessel on duty and under way carries a white all-round light, visible three miles, at the masthead and an overtaking light; she shows one or more flare-ups at intervals not exceeding 10 minutes. Bow lights are used to indicate her heading on the near approach of or to other vessels.

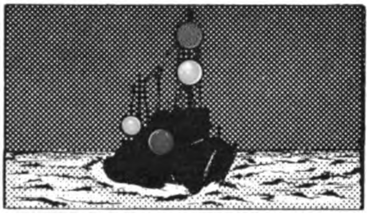
A pilot-vessel on duty and not under way shows the masthead light or lights and flare-up. When anchored she shows, in addition, anchor lights (Rule 11).

Rule 15. *A power-driven pilot-vessel on duty, in addition to the normal sound signals for power-driven vessels, may sound an identity signal of 4 short blasts.*

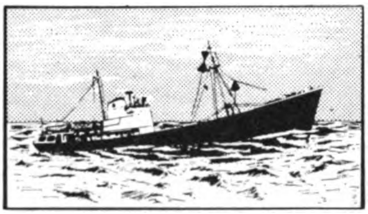
* This is not a provision of the regulations.



Trawler trawling and making way, showing optional steaming light



Fishing vessel making way and having gear extending more than 500 feet



Fishing vessel with outlying gear extending more than 500 feet

Rule 9. Vessels engaged in trawling show an all-round green light above an all-round white light, both visible two miles. They may carry in addition one steaming light, lower than and abaft the all-round green and white lights.

When making way through the water they show bow lights and overtaking light.

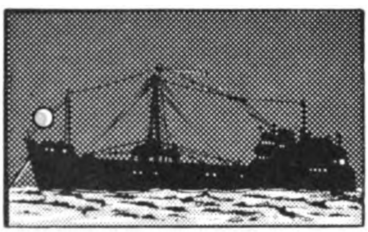
Vessels engaged in fishing, except trawling, show an all-round red light above an all-round white light. When making way through the water they show bow lights and overtaking light.

If outlying gear extends more than 500 feet an additional all-round white light shows the direction of the gear.

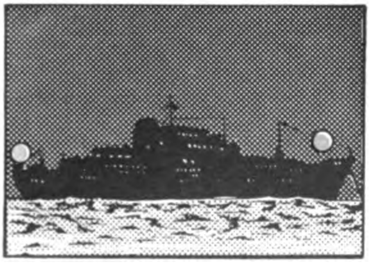
In addition, vessels engaged in fishing may use a flare-up or direct a searchlight in the direction of a danger to approaching vessels.

By day vessels engaged in fishing show a black shape consisting of two cones point to point. If less than 65 feet in length a basket may be shown instead of the black shape. If outlying gear extends more than 500 feet, a black cone, point upwards, indicates the direction of the gear.

Note: *Vessels fishing with trolling lines are not " engaged in fishing " as defined in Rule 1.*



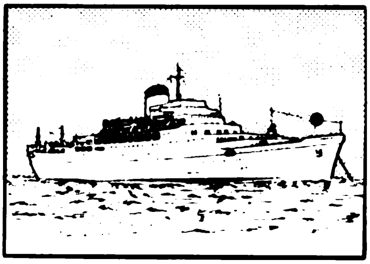
Vessel of less than 150 feet, anchored



Vessel of 150 feet or more, anchored

Rule 11. A vessel of less than 150 feet, when at anchor, carries in the forepart a white all-round light visible two miles. She may also carry a second white light as for vessels of 150 feet and over, but the visibility is two miles.

A vessel of 150 feet or more in length, when at anchor, carries two white all-round lights, visible three miles: one near the stem, the other at or near the stern and 15 feet lower.



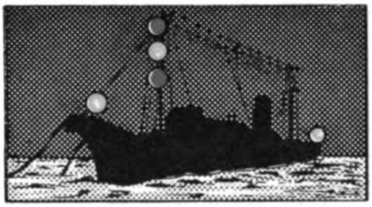
Vessel at anchor by day

Rule 11. Every vessel at anchor, by day, hoists one black ball in the forepart of the vessel.

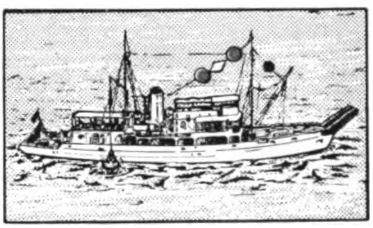
Rule 15. *In low visibility, day or night, a vessel at anchor rings her bell rapidly for about 5 seconds every minute.*

In vessels of more than 350 feet in length, the bell is sounded in the forepart and a gong or other instrument similarly in the afterpart.

A vessel at anchor may in addition sound one short, one prolonged, and one short blast to give warning of her position and of the possibility of collision to an approaching vessel.



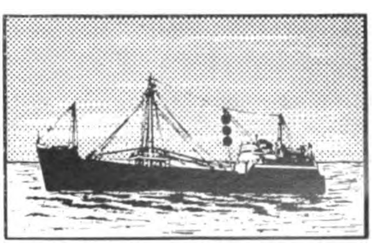
Vessel engaged in laying or picking up cable and at anchor, by night



Vessel engaged in laying or picking up a navigation mark and at anchor, by day

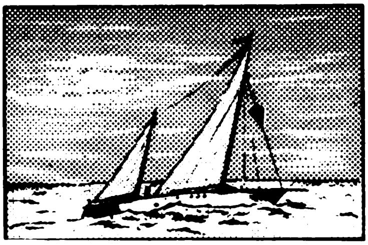
Rule 11. A vessel engaged in laying or picking up a submarine cable or navigation mark, surveying or underwater operations, when at anchor, carries the lights or shapes prescribed in Rule 4 (c) in addition to her anchor lights.

Vessel aground by night



Vessel aground by day

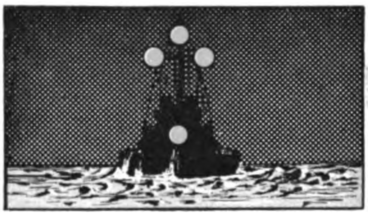
Rule 11. A vessel aground carries the light or lights for a vessel at anchor and the two red lights prescribed in Rule 4 (a). By day she carries three black balls, one above the other.



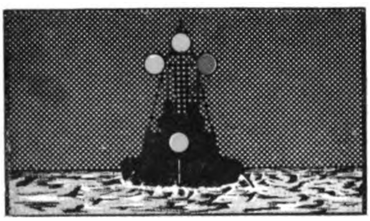
Vessel under sail and propelled by machinery

Rule 14. A vessel proceeding under sail, when also being propelled by machinery, carries one black cone point downwards.

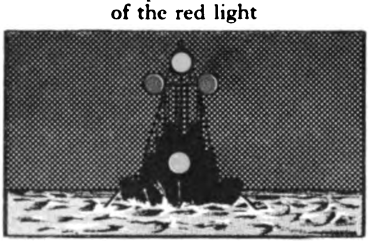
In low visibility she makes the sound signals for a power-driven vessel.



Clear both sides



Do not pass on the side of the red light



Foul both sides

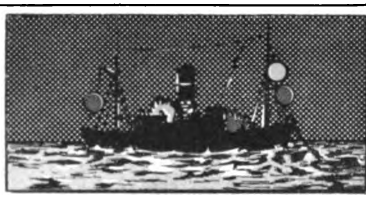
DREDGERS*

Lights and daymarks for dredgers are prescribed in local port regulations, and they may therefore differ from port to port.

The illustrations refer to dredgers working in H.M. Dockyard ports only.

Anchor lights are carried in addition to other lights.

By day black balls are hoisted in place of white lights, and red flags in place of red lights.



A light-vessel out of station at night*

A light-vessel out of station by day*

LIGHT-VESSELS*

A light-vessel when driven from her proper station strikes the distinguishing masthead marks if circumstances permit.

The characteristic light is not shown and the fog signals are not sounded. The following signals are made:

By night: A red fixed light at the bow and stern, and red and white flares shown simultaneously every 15 minutes. If the use of the flares is impracticable, a red and a white light are displayed simultaneously for about a minute.

By day: Two black balls, one forward and one aft, and the signal PC.

In fog or low visibility, a light-vessel out of position sounds the fog signal for a ship at anchor.

* This is not a provision of the "Collision Regulations".

CHAPTER 20

The Rule of the Road (1960)

Scope of the Regulations

The thirty-one Rules are divided into six parts:

A—Preliminary and Definitions

B—Lights and Shapes

C—Sound signals and conduct in restricted visibility

D—Steering and Sailing Rules

E—Sound signals for vessels in sight of one another

F—Miscellaneous.

The Steering and Sailing Rules provide for almost all occasions of two vessels or seaplanes approaching one another where risk of collision exists. They tell the seaman which vessel must give way, and describe the conditions under which he may expect the other vessel to keep clear of him.

The remaining Rules prescribe the means whereby vessels and seaplanes which are fully manoeuvrable may be identified by night or in low visibility; also the means whereby vessels or seaplanes with no power (or limited power) or with limited manoeuvrability may be distinguished by day or by night or in low visibility. By these means (i.e. the display of lights and shapes and the making of sound signals) the seaman may know instantly whether to expect another vessel to obey the Steering and Sailing Rules or whether she is unable to do so. The Rules include sound signals to be made by vessels in various circumstances, signals to be made by vessels in distress to attract attention or summon assistance, and precautions to be taken by all vessels.

Principles of the Steering and Sailing Rules

The rules for a power-driven vessel meeting another power-driven vesse depend upon the relative bearing of one ship from another; they are quite separate from the rules for a sailing vessel meeting another sailing vessel, which are governed by the direction of the wind.

The main principles upon which the Steering Rules for power-driven vessels are based are as follows:

(i) When two vessels approach end on to one another, each must give way to the other.

(ii) In all circumstances where risk of collision exists one vessel (sometimes known as the 'privileged vessel') holds her course and speed while the other (sometimes known as the 'burdened vessel') gives way.

(iii) The vessel which is directed to give way does so by altering course, or reducing speed, or stopping, or going astern.

(iv) The vessel which is directed to give way should avoid crossing close ahead of the other.

(v) In a broad sense, vessels keep to the right.

(vi) Vessels should always keep a proper look-out (which includes operating radar in low visibility), exhibit the prescribed lights and shapes, make the prescribed sound signals, and be handled in a seamanlike manner with due caution and consideration for others, especially in conditions of low visibility.

(vii) If a collision appears to be unavoidable, each vessel must take whatever action is possible to avert it or to minimise the impact, even if such action involves a departure from the normal rules.

The principle on which the Sailing Rules are based is that the vessel which would lose more ground by an alteration of course is given the right of way.

Illustrations of Lights and Shapes

The coloured plates between pages 560 and 561 show the lights and shapes described in the various rules. A brief description is given against each illustration, but the illustration must be studied with the relevant Rule.

LIST OF RULES

RULE OF THE ROAD (1960)

PART A—PRELIMINARY AND DEFINITIONS

Rule 1

(*a*) These Rules shall be followed by all vessels and seaplanes upon the high seas and in all waters connected therewith navigable by seagoing vessels, except as provided in Rule 30. Where, as a result of their special construction, it is not possible for seaplanes to comply fully with the provisions of Rules specifying the carrying of lights and shapes, these provisions shall be followed as closely as circumstances permit.

(*b*) The Rules concerning lights shall be complied with in all weathers from sunset to sunrise, and during such times no other lights shall be exhibited, except such lights as cannot be mistaken for the prescribed lights or do not impair their visibility or distinctive character, or interfere with the keeping of a proper look-out. The lights prescribed by these Rules may also be exhibited from sunrise to sunset in restricted visibility and in all other circumstances when it is deemed necessary.

(*c*) In the following Rules, except where the context otherwise requires:

(i) the word 'vessel' includes every description of water craft, other than a seaplane on the water, used or capable of being used as a means of transportation on water;

(ii) the word 'seaplane' includes a flying boat and any other aircraft designed to manoeuvre on the water;

(iii) the term 'power-driven vessel' means any vessel propelled by machinery;

(iv) every power-driven vessel which is under sail and not under power is to be considered a sailing vessel, and every vessel under power, whether under sail or not, is to be considered a power-driven vessel;

(v) a vessel or seaplane on the water is 'under way' when she is not at anchor, or made fast to the shore, or ground;

(vi) the term 'height above the hull' means height above the uppermost continuous deck;

(vii) the length and breadth of a vessel shall be her length overall and largest breadth;

(viii) the length and span of a seaplane shall be its maximum length and span as shown in its certificate of airworthiness, or as determined by measurement in the absence of such certificate;

(ix) vessels shall be deemed to be in sight of one another only when one can be observed visually from the other;

(x) the word 'visible', when applied to lights, means visible on a dark night with a clear atmosphere;

(xi) the term 'short blast' means a blast of about one second's duration;

(xii) the term 'prolonged blast' means a blast of from four to six seconds' duration;

(xiii) the word 'whistle' means any appliance capable of producing the prescribed short and prolonged blasts;

(xiv) the term 'engaged in fishing' means fishing with nets, lines or trawls, but does not include fishing with trolling lines.

PART B—LIGHTS AND SHAPES

Rule 2

(*a*) A power-driven vessel when under way shall carry:

(i) On or in front of the foremast, or if a vessel without a foremast then in the forepart of the vessel, a white light so constructed as to show an unbroken light over an arc of the horizon of 225 degrees (20 points of the compass), so fixed as to show the light 112½ degrees (10 points) on each side of the vessel, that is, from right ahead to 22½ degrees (2 points) abaft the beam on either side, and of such a character as to be visible at a distance of at least 5 miles.

(ii) Either forward or abaft the white light prescribed in sub-section (i) a second white light similar in construction and character to that light. Vessels of less than 150 feet in length shall not be required to carry this second white light but may do so.

(iii) These two white lights shall be so placed in a line with and over the keel that one shall be at least 15 feet higher than the other and in such a position that the forward light shall always be shown lower than the after one. The horizontal distance between the two white lights shall be at least three times the vertical distance. The lower of these two white lights or, if only one is carried, then that light, shall be placed at a height above the hull of not less than 20 feet, and, if the breadth of the vessel exceeds 20 feet, then at a height above the hull not less than such breadth, so however that the light need not be placed at a greater height above the hull than 40 feet. In all circumstances the light or lights, as the case may be, shall be so placed as to be clear of and above all other lights and obstructing superstructures.

(iv) On the starboard side a green light so constructed as to show an unbroken light over an arc of the horizon of 112½ degrees (10 points of the compass), so fixed as to show the light from right ahead to 22½ degrees (2 points) abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least 2 miles.

(v) On the port side a red light so constructed as to show an unbroken light over an arc of the horizon of 112½ degrees (10 points of the compass), so fixed as to show the light from right ahead to 22½ degrees (2 points) abaft the beam on the port side, and of such a character as to be visible at a distance of at least 2 miles.

(vi) The said green and red sidelights shall be fitted with inboard screens projecting at least 3 feet forward from the light, so as to prevent these lights from being seen across the bows.

(*b*) A seaplane under way on the water shall carry:

(i) In the forepart amidships where it can best be seen a white light, so constructed as to show an unbroken light over an arc of the horizon of 220 degrees of the compass, so fixed as to show the light 110 degrees on each side of the seaplane, namely, from right ahead to 20 degrees abaft the beam on either side, and of such a character as to be visible at a distance of at least 3 miles.

(ii) On the right or starboard wing tip a green light, so constructed as to show an unbroken light over an arc of the horizon of 110 degrees of the compass, so fixed as to show the light from right ahead to 20 degrees abaft the beam on the starboard side, and of such a character as to be visible at a distance of at least 2 miles.

(iii) On the left or port wing tip a red light, so constructed as to show an unbroken light over an arc of the horizon of 110 degrees of the compass, so fixed as to show the light from right ahead to 20 degrees abaft the beam on the port side, and of such a character as to be visible at a distance of at least 2 miles.

Rule 3

(*a*) A power-driven vessel when towing or pushing another vessel or seaplane shall, in addition to her sidelights, carry two white lights in a vertical line one over the other, not less than 6 feet apart, and when towing and the length of the tow, measuring from the stern of the towing vessel to the stern of the last vessel towed, exceeds 600 feet, shall carry three white lights in a vertical line one over the other, so that the upper and lower lights shall be the same distance from, and not less than 6 feet above or below the middle light. Each of these lights shall be of the same construction and character and one of them shall be carried in the same position as the white light prescribed in Rule 2 (*a*) (i). None of these lights shall be carried at a height of less than 14 feet above the hull. In a vessel with a single mast, such lights may be carried on the mast.

(*b*) The towing vessel shall also show either the stern light prescribed in Rule 10 or in lieu of that light a small white light abaft the funnel or aftermast for the tow to steer by, but such light shall not be visible forward of the beam.

(*c*) Between sunrise and sunset a power-driven vessel engaged in towing, if the length of tow exceeds 600 feet, shall carry, where it can best be seen, a black diamond shape at least 2 feet in diameter.

(*d*) A seaplane on the water, when towing one or more seaplanes or vessels, shall carry the lights prescribed in Rule 2 (*b*) (i), (ii) and (iii); and, in addition, she shall carry a second white light of the same construction and character as the white light prescribed in Rule 2 (*b*) (i), and in a vertical line at least 6 feet above or below such light.

Rule 4

(*a*) A vessel which is not under command shall carry, where they can best be

seen, and, if a power-driven vessel, in lieu of the lights prescribed in Rule 2 (*a*) (i) and (ii), two red lights in a vertical line one over the other not less than 6 feet apart, and of such a character as to be visible all round the horizon at a distance of at least 2 miles. By day, she shall carry in a vertical line one over the other not less than 6 feet apart, where they can best be seen, two black balls or shapes each not less than 2 feet in diameter.

(*b*) A seaplane on the water which is not under command may carry, where they can best be seen, and in lieu of the light prescribed in Rule 2 (*b*) (i), two red lights in a vertical line, one over the other, not less than 3 feet apart, and of such a character as to be visible all round the horizon at a distance of at least 2 miles, and may by day carry in a vertical line one over the other not less than 3 feet apart, where they can best be seen, two black balls or shapes, each not less than 2 feet in diameter.

(*c*) A vessel engaged in laying or in picking up a submarine cable or navigation mark, or a vessel engaged in surveying or underwater operations, or a vessel engaged in replenishment at sea, or in the launching or recovery of aircraft when from the nature of her work she is unable to get out of the way of approaching vessels, shall carry, in lieu of the lights prescribed in Rule 2 (*a*) (i) and (ii), or Rule 7 (*a*) (i), three lights in a vertical line one over the other so that the upper and lower lights shall be the same distance from, and not less than 6 feet above or below, the middle light. The highest and lowest of these lights shall be red, and the middle light shall be white, and they shall be of such a character as to be visible all round the horizon at a distance of at least 2 miles. By day, she shall carry in a vertical line one over the other not less than 6 feet apart, where they can best be seen, three shapes each not less than 2 feet in diameter, of which the highest and lowest shall be globular in shape and red in colour, and the middle one diamond in shape and white.

(*d*) (i) A vessel engaged in minesweeping operations shall carry at the fore truck a green light, and at the end or ends of the fore yard on the side or sides on which danger exists, another such light or lights. These lights shall be carried in addition to the light prescribed in Rule 2 (*a*) (i) or Rule 7 (*a*) (i), as appropriate, and shall be of such a character as to be visible all round the horizon at a distance of at least 2 miles. By day she shall carry black balls, not less than 2 feet in diameter, in the same position as the green lights.

(ii) The showing of these lights or balls indicates that it is dangerous for other vessels to approach closer than 3000 feet astern of the minesweeper or 1500 feet on the side or sides on which danger exists.

(*e*) The vessels and seaplanes referred to in this Rule, when not making way through the water, shall show neither the coloured sidelights nor the stern light, but when making way they shall show them.

(*f*) The lights and shapes prescribed in this Rule are to be taken by other vessels and seaplanes as signals that the vessel or seaplane showing them is not under command and cannot therefore get out of the way.

(*g*) These signals are not signals of vessels in distress and requiring assistance. Such signals are contained in Rule 31.

Rule 5

(*a*) A sailing vessel under way and any vessel or seaplane being towed shall carry the same lights as are prescribed in Rule 2 for a power-driven vessel or a seaplane under way, respectively, with the exception of the white lights prescribed therein, which they shall never carry. They shall also carry stern lights as prescribed in Rule 10, provided that vessels towed, except the last vessel of a tow, may carry, in lieu of such stern light, a small white light as prescribed in Rule 3 (*b*).

(*b*) In addition to the lights prescribed in section (*a*), a sailing vessel may carry on the top of the foremast two lights in a vertical line one over the other, sufficiently separated so as to be clearly distinguished. The upper light shall be red and the lower light shall be green. Both lights shall be constructed and fixed as prescribed in Rule 2 (*a*) (i) and shall be visible at a distance of at least 2 miles.

(*c*) A vessel being pushed ahead shall carry, at the forward end, on the starboard side a green light and on the port side a red light, which shall have the same characteristics as the lights prescribed in Rule 2 (*a*) (iv) and (v) and shall be screened as provided in Rule 2 (*a*) (vi), provided that any number of vessels pushed ahead in a group shall be lighted as one vessel.

(*d*) Between sunrise and sunset a vessel being towed, if the length of the tow exceeds 600 feet, shall carry where it can best be seen a black diamond shape at least 2 feet in diameter.

Rule 6

(*a*) When it is not possible on account of bad weather or other sufficient cause to fix the green and red sidelights, these lights shall be kept at hand lighted and ready for immediate use, and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side, nor, if practicable, more than 22½ degrees (2 points) abaft the beam on their respective sides.

(*b*) To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the colour of the lights they respectively contain, and shall be provided with proper screens.

Rule 7

Power-driven vessels of less than 65 feet in length, vessels under oars or sails of less than 40 feet in length, and rowing boats, when under way shall not be required to carry the lights prescribed in Rules 2, 3 and 5, but if they do not carry them they shall be provided with the following lights:

(*a*) Power-driven vessels of less than 65 feet in length, except as provided in sections (*b*) and (*c*) shall carry:

(i) In the forepart of the vessel, where it can best be seen, and at a height above the gunwale of not less than 9 feet, a white light constructed and fixed as prescribed in Rule 2 (*a*) (i) and of such a character as to be visible at a distance of at least 3 miles.

(ii) Green and red sidelights constructed and fixed as prescribed in Rule 2 (*a*) (iv) and (v), and of such a character as to be visible at a distance of at least 1 mile, or a combined lantern showing a green light and a red light from right ahead to $22\frac{1}{2}$ degrees (2 points) abaft the beam on their respective sides. Such lantern shall be carried not less than 3 feet below the white light.

(*b*) Power-driven vessels of less than 65 feet in length when towing or pushing another vessel shall carry:

(i) In addition to the sidelights or the combined lantern prescribed in section (*a*) (ii) two white lights in a vertical line, one over the other not less than 4 feet apart. Each of these lights shall be of the same construction and character as the white light prescribed in section (*a*) (i) and one of them shall be carried in the same position. In a vessel with a single mast such lights may be carried on the mast.

(ii) Either a stern light as prescribed in Rule 10 or in lieu of that light a small white light abaft the funnel or aftermast for the tow to steer by, but such light shall not be visible forward of the beam.

(*c*) Power-driven vessels of less than 40 feet in length may carry the white light at a less height than 9 feet above the gunwale but it shall be carried not less than 3 feet above the sidelights or the combined lantern prescribed in section (*a*) (ii).

(*d*) Vessels of less than 40 feet in length, under oars or sails, except as provided in section (*f*), shall, if they do not carry the sidelights, carry, where it can best be seen, a lantern showing a green light on one side and a red light on the other, of such a character as to be visible at a distance of at least 1 mile, and so fixed that the green light shall not been seen on the port side, nor the red light on the starboard side. Where it is not possible to fix this light, it shall be kept ready for immediate use and shall be exhibited in sufficient time to prevent collision and so that the green light shall not be seen on the port side nor the red light on the starboard side.

(*e*) The vessels referred to in this Rule when being towed shall carry the sidelights or the combined lantern prescribed in sections (*a*) or (*d*) of this Rule, as appropriate, and a stern light as prescribed in Rule 10, or, except the last vessel of the tow, a small white light as prescribed in section (*b*) (ii). When being pushed ahead they shall carry at the forward end the sidelights or combined lantern prescribed in sections (*a*) or (*d*) of this Rule, as appropriate, provided that any number of vessels referred to in this Rule when pushed ahead in a group shall be lighted as one vessel under this Rule unless the overall length of the group exceeds 65 feet when the provisions of Rule 5 (*c*) shall apply.

(*f*) Small rowing boats, whether under oars or sail, shall only be required to have ready at hand an electric torch or a lighted lantern, showing a white light, which shall be exhibited in sufficient time to prevent collision.

(*g*) The vessels and boats referred to in this Rule shall not be required to carry the lights or shapes prescribed in Rules 4 (*a*) and 11 (*e*) and the size of their day signals may be less than is prescribed in Rules 4 (*c*) and 11 (*c*).

Rule 8

(*a*) A power-driven pilot-vessel when engaged on pilotage duty and under way:

(i) Shall carry a white light at the masthead at a height of not less than 20 feet above the hull, visible all round the horizon at a distance of at least 3 miles and at a distance of 8 feet below it a red light similar in construction and character. If such a vessel is of less than 65 feet in length she may carry the white light at a height of not less than 9 feet above the gunwale and the red light at a distance of 4 feet below the white light.

(ii) Shall carry the sidelights or lanterns prescribed in Rule 2 (*a*) (iv) and (v) or Rule 7 (*a*) (ii) or (*d*), as appropriate, and the stern light prescribed in Rule 10.

(iii) Shall show one or more flare-up lights at intervals not exceeding 10 minutes. An intermittent white light visible all round the horizon may be used in lieu of flare-up lights.

(*b*) A sailing pilot-vessel when engaged on pilotage duty and under way:

(i) Shall carry a white light at the masthead visible all round the horizon at a distance of at least 3 miles.

(ii) Shall be provided with the sidelights or lantern prescribed in Rules 5 (*a*) or 7 (*d*), as appropriate, and shall, on the near approach of or to other vessels, have such lights ready for use, and shall show them at short intervals to indicate the direction in which she is heading, but the green light shall not be shown on the port side nor the red light on the starboard side. She shall also carry the stern light prescribed in Rule 10.

(iii) Shall show one or more flare-up lights at intervals not exceeding 10 minutes.

(*c*) A pilot-vessel when engaged on pilotage duty and not under way shall carry the lights and show the flares prescribed in sections (*a*) (i) and (iii) or (*b*) (i) and (iii), as appropriate, and if at anchor shall also carry the anchor lights prescribed in Rule 11.

(*d*) A pilot-vessel when not engaged on pilotage duty shall show the lights or shapes for a similar vessel of her length.

Rule 9

(*a*) Fishing vessels when not engaged in fishing shall show the lights or shapes for similar vessels of their length.

(*b*) Vessels engaged in fishing, when under way or at anchor, shall show only the lights and shapes prescribed in this Rule, which lights and shapes shall be visible at a distance of at least 2 miles.

(*c*) (i) Vessels when engaged in trawling, by which is meant the dragging of a dredge net or other apparatus through the water, shall carry two lights in a vertical line, one over the other, not less than 4 feet nor more than 12 feet apart. The upper of these lights shall be green and the lower light white and each shall be visible all round the horizon. The lower of these two lights shall be carried at a height above the

sidelights not less than twice the distance between the two vertical lights.

(ii) Such vessels may in addition carry a white light similar in construction to the white light prescribed in Rule 2 (*a*) (i), but such light shall be carried lower than and abaft the all-round green and white lights.

(*d*) Vessels when engaged in fishing, except vessels engaged in trawling, shall carry the lights prescribed in section (*c*) (i) except that the upper of the two vertical lights shall be red. Such vessels if of less than 40 feet in length may carry the red light at a height of not less than 9 feet above the gunwale and the white light not less than 3 feet below the red light.

(*e*) Vessels referred to in sections (*c*) and (*d*), when making way through the water, shall carry the sidelights or lanterns prescribed in Rule 2 (*a*) (iv) and (v) or Rule 7 (*a*) (ii) or (*d*), as appropriate, and the stern light prescribed in Rule 10. When not making way through the water they shall show neither the sidelights nor the stern light.

(*f*) Vessels referred to in section (*d*) with outlying gear extending more than 500 feet horizontally into the seaway shall carry an additional all-round white light at a horizontal distance of not less than 6 feet nor more than 20 feet away from the vertical lights in the direction of the outlying gear. This additional white light shall be placed at a height not exceeding that of the white light prescribed in section (*c*) (i) and not lower than the sidelights.

(*g*) In addition to the lights which they are required by this Rule to carry, vessels engaged in fishing may, if necessary in order to attract the attention of an approaching vessel, use a flare-up light, or may direct the beam of their searchlight in the direction of a danger threatening the approaching vessel, in such a way as not to embarrass other vessels. They may also use working lights, but fishermen shall take into account that specially bright or insufficiently screened working lights may impair the visibility and distinctive character of the lights prescribed in this Rule.

(*h*) By day vessels when engaged in fishing shall indicate their occupation by displaying where it can best be seen a black shape consisting of two cones each not less than 2 feet in diameter with their points together one above the other. Such vessels if of less than 65 feet in length may substitute a basket for such black shape. If their outlying gear extends more than 500 feet horizontally into the seaway vessels engaged in fishing shall display in addition one black conical shape, point upwards, in the direction of the outlying gear.

Note: Vessels fishing with trolling lines are not 'engaged in fishing' as defined in Rule 1 (*c*) (xiv).

Rule 10

(*a*) Except where otherwise provided in these Rules, a vessel when under way shall carry at her stern a white light, so constructed that it shall show an unbroken light over an arc of the horizon of 135 degrees (12 points of the compass), so fixed as to show the light 67½ degrees (6 points) from right aft on each side of the vessel, and of such a character as to be visible at a distance of at least 2 miles.

(*b*) In a small vessel, if it is not possible on account of bad weather or other

sufficient cause for this light to be fixed, an electric torch or a lighted lantern showing a white light shall be kept at hand ready for use and shall, on the approach of an overtaking vessel, be shown in sufficient time to prevent collision.

(*c*) A seaplane on the water when under way shall carry on her tail a white light, so constructed as to show an unbroken light over an arc of the horizon of 140 degrees of the compass, so fixed as to show the light 70 degrees from right aft on each side of the seaplane, and of such a character as to be visible at a distance of at least 2 miles.

Rule 11

(*a*) A vessel of less than 150 feet in length, when at anchor, shall carry in the forepart of the vessel, where it can best be seen, a white light visible all round the horizon at a distance of at least 2 miles. Such a vessel may also carry a second white light in the position prescribed in section (*b*) of this Rule but shall not be required to do so. The second white light, if carried, shall be visible at a distance of at least 2 miles and so placed as to be as far as possible visible all round the horizon.

(*b*) A vessel of 150 feet or more in length, when at anchor, shall carry near the stem of the vessel, at a height of not less than 20 feet above the hull, one such light, and at or near the stern of the vessel and at such a height that it shall be not less than 15 feet lower than the forward light, another such light. Both these lights shall be visible at a distance of at least 3 miles and so placed as to be as far as possible visible all round the horizon.

(*c*) Between sunrise and sunset every vessel when at anchor shall carry in the forepart of the vessel, where it can best be seen, one black ball not less than 2 feet in diameter.

(*d*) A vessel engaged in laying or in picking up a submarine cable or navigation mark, or a vessel engaged in surveying or underwater operations, when at anchor, shall carry the lights or shapes prescribed in Rule 4 (*c*) in addition to those prescribed in the appropriate preceding sections of this Rule.

(*e*) A vessel aground shall carry the light or lights prescribed in sections (*a*) or (*b*) and the two red lights prescribed in Rule 4 (*a*). By day she shall carry, where they can best be seen, three black balls, each not less than 2 feet in diameter, placed in a vertical line one over the other, not less than 6 feet apart.

(*f*) A seaplane on the water under 150 feet in length, when at anchor, shall carry, where it can best be seen, a white light, visible all round the horizon at a distance of at least 2 miles.

(*g*) A seaplane on the water 150 feet or upwards in length, when at anchor, shall carry, where they can best be seen, a white light forward and a white light aft, both lights visible all round the horizon at a distance of at least 3 miles; and, in addition, if the seaplane is more than 150 feet in span, a white light on each side to indicate the maximum span, and visible, so far as practicable, all round the horizon at a distance of 1 mile.

(*h*) A seaplane aground shall carry an anchor light or lights as prescribed in sections (*f*) and (*g*), and in addition may carry two red lights in a vertical line, at least 3 feet apart, so placed as to be visible all round the horizon.

Rule 12

Every vessel or seaplane on the water may, if necessary in order to attract attention, in addition to the lights which she is by these Rules required to carry, show a flare-up light or use a detonating or other efficient sound signal that cannot be mistaken for any signal authorised elsewhere under these Rules.

Rule 13

(*a*) Nothing in these Rules shall interfere with the operation of any special rules made by the Government of any nation with respect to additional station and signal lights for ships of war, for vessels sailing under convoy, for fishing vessels engaged in fishing as a fleet or for seaplanes on the water.

(*b*) Whenever the Government concerned shall have determined that a naval or other military vessel or waterborne seaplane of special construction or purpose cannot comply fully with the provisions of any of these Rules with respect to the number, position, range or arc of visibility of lights or shapes, without interfering with the military function of the vessel or seaplane, such vessel or seaplane shall comply with such other provisions in regard to the number, position, range or arc of visibility of lights or shapes as her Government shall have determined to be the closest possible compliance with these Rules in respect of that vessel or seaplane.

Rule 14

A vessel proceeding under sail, when also being propelled by machinery, shall carry in the daytime forward, where it can best be seen, one black conical shape, point downwards, not less than 2 feet in diameter at its base.

PART C—SOUND SIGNALS AND CONDUCT IN RESTRICTED VISIBILITY

Preliminary

1. The possession of information obtained from radar does not relieve any vessel of the obligation of conforming strictly with the Rules and, in particular, the obligations contained in Rules 15 and 16.

2. The Annex to the Rules contains recommendations intended to assist in the use of radar as an aid to avoiding collision in restricted visibility.

Rule 15

(*a*) A power-driven vessel of 40 feet or more in length shall be provided with an efficient whistle, sounded by steam or by some substitute for steam, so placed that the sound may not be intercepted by any obstruction, and with an efficient fog horn to be sounded by mechanical means, and also with an efficient bell. A sailing vessel of 40 feet or more in length shall be provided with a similar fog horn and bell.

(*b*) All signals prescribed in this Rule for vessels under way shall be given:

(i) by power-driven vessels on the whistle;

(ii) by sailing vessels on the fog horn;

(iii) by vessels towed on the whistle or fog horn.

(*c*) In fog, mist, falling snow, heavy rainstorms, or any other condition similarly restricting visibility, whether by day or night, the signals prescribed in this Rule shall be used as follows:

(i) A power-driven vessel making way through the water shall sound at intervals of not more than 2 minutes a prolonged blast.

(ii) A power-driven vessel under way, but stopped and making no way through the water, shall sound at intervals of not more than 2 minutes two prolonged blasts, with an interval of about 1 second between them.

(iii) A sailing vessel under way shall sound, at intervals of not more than 1 minute, when on the starboard tack one blast, when on the port tack two blasts in succession, and when with the wind abaft the beam three blasts in succession.

(iv) A vessel when at anchor shall at intervals of not more than 1 minute ring the bell rapidly for about 5 seconds. In vessels of more than 350 feet in length the bell shall be sounded in the forepart of the vessel, and in addition there shall be sounded in the after part of the vessel, at intervals of not more than 1 minute for about 5 seconds, a gong or other instrument, the tone and sounding of which cannot be confused with that of the bell. Every vessel at anchor may in addition, in accordance with Rule 12, sound three blasts in succession, namely, one short, one prolonged, and one short blast, to give warning of her position and of the possibility of collision to an approaching vessel.

(v) A vessel when towing, a vessel engaged in laying or in picking up a submarine cable or navigation mark, and a vessel under way which is unable to get out of the way of an approaching vessel through being not under command or unable to manoeuvre as required by these Rules shall, instead of the signals prescribed in sub-sections (i), (ii) and (iii) sound, at intervals of not more than 1 minute, three blasts in succession, namely, one prolonged blast followed by two short blasts.

(vi) A vessel towed, or, if more than one vessel is towed, only the last vessel of the tow, if manned, shall, at intervals of not more than 1 minute, sound four blasts in succession, namely, one prolonged blast followed by three short blasts. When practicable, this signal shall be made immediately after the signal made by the towing vessel.

(vii) A vessel aground shall give the bell signal and, if required, the gong signal, prescribed in sub-section (iv) and shall, in addition, give three separate and distinct strokes on the bell immediately before and after such rapid ringing of the bell.

(viii) A vessel engaged in fishing when under way or at anchor shall at intervals of not more than 1 minute sound the signal prescribed in sub-section (v). A vessel when fishing with trolling lines and under way shall sound the signals prescribed in sub-sections (i), (ii) or (iii) as may be appropriate.

(ix) A vessel of less than 40 feet in length, a rowing boat, or a seaplane on the water, shall not be obliged to give the above-mentioned signals, but, if she does not, she shall make some other efficient sound signal at intervals of not more than 1 minute.

(x) A power-driven pilot-vessel when engaged on pilotage duty may, in addition to the signals prescribed in sub-sections (i), (ii) and (iv), sound an identity signal consisting of four short blasts.

Rule 16

(*a*) Every vessel, or seaplane when taxi-ing on the water, shall, in fog, mist, falling snow, heavy rainstorms or any other condition similarly restricting visibility, go at a moderate speed, having careful regard to the existing circumstances and conditions.

(*b*) A power-driven vessel hearing, apparently forward of her beam, the fog-signal of a vessel the position of which is not ascertained, shall, so far as the circumstances of the case admit, stop her engines, and then navigate with caution until danger of collision is over.

(*c*) A power-driven vessel which detects the presence of another vessel forward of her beam before hearing her fog signal or sighting her visually may take early and substantial action to avoid a close-quarters situation, but if this cannot be avoided, she shall, so far as the circumstances of the case admit, stop her engines in proper time to avoid collision and then navigate with caution until danger of collision is over.

PART D—STEERING AND SAILING RULES

Preliminary

1. In obeying and construing these Rules, any action taken should be positive, in ample time, and with due regard to the observance of good seamanship.

2. Risk of collision can, when circumstances permit, be ascertained by carefully watching the compass bearing of an approaching vessel. If the bearing does not appreciably change, such risk should be deemed to exist.

3. Mariners should bear in mind that seaplanes in the act of landing or taking off, or operating under adverse weather conditions, may be unable to change their intended action at the last moment.

4. Rules 17 to 24 apply only to vessels in sight of one another.

Rule 17

(*a*) When two sailing vessels are approaching one another, so as to involve risk of collision, one of them shall keep out of the way of the other as follows:

(i) When each has the wind on a different side, the vessel which has the wind on the port side shall keep out of the way of the other.

(ii) When both have the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

(*b*) For the purposes of this Rule the windward side shall be deemed to be the side opposite to that on which the mainsail is carried or, in the case of a square-rigged vessel, the side opposite to that on which the largest fore-and-aft sail is carried.

Rule 18

(*a*) When two power-driven vessels are meeting end on, or nearly end on, so as to involve risk of collision, each shall alter her course to starboard, so that each may pass on the port side of the other. This Rule only applies to cases where vessels are meeting end on, or nearly end on, in such a manner as to involve risk of collision, and does not apply to two vessels which must, if both keep on their respective courses, pass clear of each other. The only cases to which it does apply are when each of two vessels is end on, or nearly end on, to the other; in other words, to cases in which, by day, each vessel sees the masts of the other in a line, or nearly in a line, with her own; and by night, to cases in which each vessel is in such a position as to see both the sidelights of the other. It does not apply, by day, to cases in which a vessel sees another ahead crossing her own course; or, by night, to cases where the red light of one vessel is opposed to the red light of the other or where the green light of one vessel is opposed to the green light of the other or where a red light without a green light or a green light without a red light is seen ahead, or where both green and red lights are seen anywhere but ahead.

(*b*) For the purposes of this Rule and Rules 19 to 29 inclusive, except Rule 20 (*c*) and Rule 28, a seaplane on the water shall be deemed to be a vessel, and the expression 'power-driven vessel' shall be construed accordingly.

Rule 19

When two power-driven vessels are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

Rule 20

(*a*) When a power-driven vessel and a sailing vessel are proceeding in such directions as to involve risk of collision, except as provided for in Rules 24 and 26, the power-driven vessel shall keep out of the way of the sailing vessel.

(*b*) This Rule shall not give to a sailing vessel the right to hamper, in a narrow channel, the safe passage of a power-driven vessel which can navigate only inside such channel.

(*c*) A seaplane on the water shall, in general, keep well clear of all vessels and avoid impeding their navigation. In circumstances, however, where risk of collision exists, she shall comply with these Rules.

Rule 21

Where by any of these Rules one of two vessels is to keep out of the way, the other shall keep her course and speed. When, from any cause, the latter vessel finds herself so close that collision cannot be avoided by the action of the

giving-way vessel alone, she also shall take such action as will best aid to avert collision (*see* Rules 27 and 29).

Rule 22

Every vessel which is directed by these Rules to keep out of the way of another vessel shall, so far as possible, take positive early action to comply with this obligation, and shall, if the circumstances of the case admit, avoid crossing ahead of the other.

Rule 23

Every power-driven vessel which is directed by these Rules to keep out of the way of another vessel shall, on approaching her, if necessary, slacken her speed or stop or reverse.

Rule 24

(*a*) Notwithstanding anything contained in these Rules, every vessel overtaking any other shall keep out of the way of the overtaken vessel.

(*b*) Every vessel coming up with another vessel from any direction more than 22½ degrees (2 points) abaft her beam, i.e. in such a position, with reference to the vessel which she is overtaking, that at night she would be unable to see either of that vessel's sidelights, shall be deemed to be an overtaking vessel; and no subsequent alteration of the bearing between the two vessels shall make the overtaking vessel a crossing vessel within the meaning of these Rules, or relieve her of the duty to keep clear of the overtaken vessel until she is finally past and clear.

(*c*) If the overtaking vessel cannot determine with certainty whether she is forward of or abaft this direction from the other vessel, she shall assume that she is an overtaking vessel and keep out of the way.

Rule 25

(*a*) In a narrow channel every power-driven vessel when proceeding along the course of the channel shall, when it is safe and practicable, keep to that side of the fairway or mid-channel which lies on the starboard side of such vessel.

(*b*) Whenever a power-driven vessel is nearing a bend in a channel where a vessel approaching from the other direction cannot be seen, such power-driven vessel, when she shall have arrived within one-half (½) mile of the bend, shall give a signal by one prolonged blast on her whistle which signal shall be answered by a similar blast given by any approaching power-driven vessel that may be within hearing around the bend. Regardless of whether an approaching vessel on the farther side of the bend is heard, such bend shall be rounded with alertness and caution.

(*c*) In a narrow channel a power-driven vessel of less than 65 feet in length shall not hamper the safe passage of a vessel which can navigate only inside such channel.

Rule 26

All vessels not engaged in fishing, except vessels to which the provisions of

Rule 4 apply, shall, when under way, keep out of the way of vessels engaged in fishing. This Rule shall not give to any vessel engaged in fishing the right of obstructing a fairway used by vessels other than fishing vessels.

Rule 27

In obeying and construing these Rules due regard shall be had to all dangers of navigation and collision, and to any special circumstances, including the limitations of the craft involved, which may render a departure from the above Rules necessary in order to avoid immediate danger.

PART E—SOUND SIGNALS FOR VESSELS IN SIGHT OF ONE ANOTHER

Rule 28

(*a*) When vessels are in sight of one another, a power-driven vessel under way, in taking any course authorised or required by these Rules, shall indicate that course by the following signals on her whistle, namely:

One short blast to mean 'I am altering my course to starboard'.

Two short blasts to mean 'I am altering my course to port'.

Three short blasts to mean 'My engines are going astern'.

(*b*) Whenever a power-driven vessel which, under these Rules, is to keep her course and speed, is in sight of another vessel and is in doubt whether sufficient action is being taken by the other vessel to avert collision, she may indicate such doubt by giving at least five short and rapid blasts on the whistle. The giving of such a signal shall not relieve a vessel of her obligations under Rules 27 and 29 or any other Rule, or of her duty to indicate any action taken under these Rules by giving the appropriate sound signals laid down in this Rule.

(*c*) Any whistle signal mentioned in this Rule may be further indicated by a visual signal consisting of a white light visible all round the horizon at a distance of at least 5 miles, and so devised that it will operate simultaneously and in conjunction with the whistle-sounding mechanism and remain lighted and visible during the same period as the sound signal.

(*d*) Nothing in these Rules shall interfere with the operation of any special rules made by the Government of any nation with respect to the use of additional whistle signals between ships of war or vessels sailing under convoy.

PART F—MISCELLANEOUS

Rule 29

Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution

which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

Rule 30

Nothing in these Rules shall interfere with the operation of a special rule duly made by local authority relative to the navigation of any harbour, river, lake, or inland water, including a reserved seaplane area.

Rule 31

Distress Signals

(*a*) When a vessel or seaplane on the water is in distress and requires assistance from other vessels or from the shore, the following shall be the signals to be used or displayed by her, either together or separately, namely:

(i) A gun or other explosive signal fired at intervals of about a minute.

(ii) A continuous sounding with any fog-signalling apparatus.

(iii) Rockets or shells, throwing red stars fired one at a time at short intervals.

(iv) A signal made by radiotelegraphy or by any other signalling method consisting of the group • • • ▬ ▬ ▬ • • • in the Morse Code.

(v) A signal sent by radiotelephony consisting of the spoken word 'Mayday'.

(vi) The International Code Signal of distress indicated by NC.

(vii) A signal consisting of a square flag having above or below it a ball or anything resembling a ball.

(viii) Flames on the vessel (as from a burning tar barrel, oil barrel, etc.).

(ix) A rocket parachute flare or a hand flare showing a red light.

(x) A smoke signal giving off a volume of orange-coloured smoke.

(xi) Slowly and repeatedly raising and lowering arms outstretched to each side.

Note: Vessels in distress may use the radiotelegraph alarm signal or the radiotelephone alarm signal to secure attention to distress calls and messages. The radiotelegraph alarm signal, which is designed to actuate the radiotelegraph auto alarms of vessels so fitted, consists of a series of twelve dashes, sent in 1 minute, the duration of each dash being 4 seconds, and the duration of the interval between 2 consecutive dashes being 1 second. The radiotelephone alarm signal consists of two tones transmitted alternately over periods of from 30 seconds to 1 minute.

(*b*) The use of any of the foregoing signals, except for the purpose of indicating that a vessel or seaplane is in distress, and the use of any signals which may be confused with any of the above signals, is prohibited.

ANNEX TO THE RULES

Recommendations on the Use of Radar Information as an Aid to Avoiding Collisions at Sea

(1) Assumptions made on scanty information may be dangerous and should be avoided.

(2) A vessel navigating with the aid of radar in restricted visibility must, in compliance with Rule 16 (*a*), go at a moderate speed. Information obtained from the use of radar is one of the circumstances to be taken into account when determining moderate speed. In this regard it must be recognised that small vessels, small icebergs and similar floating objects may not be detected by radar.

Radar indications of one or more vessels in the vicinity may mean that 'moderate speed' should be slower than a mariner without radar might consider moderate in the circumstances.

(3) When navigating in restricted visibility the radar range and bearing alone do not constitute ascertainment of the position of the other vessel under Rule 16 (*b*) sufficiently to relieve a vessel of the duty to stop her engines and navigate with caution when a fog signal is heard forward of the beam.

(4) When action has been taken under Rule 16 (*c*) to avoid a close-quarters tuation, it is essential to make sure that such action is having the desired effect. Alterations of course or speed or both are matters as to which the mariner must be guided by the circumstances of the case.

(5) Alteration of course alone may be the most effective action to avoid close quarters provided that:

(*a*) There is sufficient sea room.

(*b*) It is made in good time.

(*c*) It is substantial. A succession of small alterations of course should be avoided.

(*d*) It does not result in a close-quarters situation with other vessels.

(6) The direction of an alteration of course is a matter in which the mariner must be guided by the circumstances of the case. An alteration to starboard, particularly when vessels are approaching apparently on opposite or nearly opposite courses, is generally preferable to an alteration to port.

(7) An alteration of speed, either alone or in conjunction with an alteration of course, should be substantial. A number of small alterations of speed should be avoided.

(8) If a close-quarters situation is imminent, the most prudent action may be to take all way off the vessel.

A SUMMARY OF SOUND SIGNALS

	SIGNAL	MADE ON	INTERVAL	SIGNIFICATION	AUTHORITY
—	One prolonged blast	Whistle	At least every 2 minutes	In fog—power-driven vessel making way through the water	Rule 15 (*c*) (i)
— —	Two prolonged blasts	Whistle	At least every 2 minutes	In fog—power-driven vessel under way but stopped and making no way through the water	Rule 15 (*c*) (ii)
— · ·	One prolonged and two short blasts	Whistle	At least every minute	In fog—(i) power-driven vessel towing (ii) cable-laying ship, etc., at work (iii) power-driven vessel not under command, whether making way through the water or not (iv) a power-driven vessel not able to manoeuvre as required by the Rules, e.g. a minesweeper with sweeps out (v) a power-driven vessel engaged in fishing when under way or at anchor	Rule 15 (*c*) (v) Rule 15 (*c*) (viii)
— · · ·	One prolonged and three short blasts	Whistle or fog horn	At least every minute	In fog—a vessel being towed	Rule 15 (*c*) (vi)
—	One blast	Fog horn	At least every minute	In fog—a sailing vessel under way on the starboard tack	Rule 15 (*c*) (iii)
— —	Two blasts	Fog horn	At least every minute	In fog—a sailing vessel under way on the port tack	Rule 15 (*c*) (iii)
— — —	Three blasts	Fog horn	At least every minute	In fog—a sailing vessel under way with the wind abaft the beam	Rule 15 (*c*) (iii)
— · ·	One prolonged and two short blasts	Fog horn	At least every minute	In fog—(i) a sailing vessel towing (ii) a sailing vessel not under command, whether making way through the water or not (iii) a sailing vessel not able to manoeuvre as required by the Rules, e.g. becalmed or in irons (iv) a vessel engaged in fishing	Rule 15 (*c*) (v)

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A SUMMARY OF SOUND SIGNALS—(*continued*)

SIGNAL	MADE ON	INTERVAL	SIGNIFICATION	AUTHORITY
• • • • Four short blasts	Whistle	—	In fog—a power-driven pilot vessel, on duty, under way, stopped or at anchor, in addition to the normal signals	Rule 15 (*c*) (x)
5 seconds' ringing	Bell	At least every minute	In fog—a vessel at anchor	Rule 15 (*c*) (iv)
3 strokes followed by 5 seconds' rapid ringing, followed by 3 strokes	Bell	At least every minute	In fog—a vessel aground	Rule 15 (*c*) (vii)
• One short blast	Whistle	—	By a power-driven vessel in sight of another—I am altering my course to starboard	Rule 28 (*a*)
• • Two short blasts	Whistle	—	By a power-driven vessel in sight of another—I am altering my course to port	Rule 28 (*a*)
• • • Three short blasts	Whistle	—	By a power-driven vessel in sight of another—My engines are going astern	Rule 28 (*a*)
• • • • • Five or more short blasts	Whistle	—	By a holding-on power-driven vessel in sight of the giving-way power-driven vessel—I am in doubt whether you are taking sufficient action to avert collision	Rule 28 (*b*)
— • • One prolonged and two short blasts	Whistle	—	In H.M. Dockyard Ports—Keep out of my way, because I cannot keep out of yours	—
• • • • • Four short blasts followed by one short blast	Whistle	—	In H.M. Dockyard Ports—My ship is practically stopped, but turning to starboard	—
• • • • • • Four short blasts followed by two short blasts	Whistle	—	In H.M. Dockyard Ports—My ship is practically stopped, but turning to port	—
• • • — — — • • • SOS	Whistle or fog horn	—	A signal of distress	Rule 31

SIGNAL	MADE ON	INTERVAL	SIGNIFICATION	AUTHORITY
· · — · F	Whistle	—	I am disabled; communicate with me	International Code of Signals
— — · G	Whistle	—	I require a pilot	International Code of Signals
— · — K	Whistle	—	You should stop your ship instantly	International Code of Signals
· — · · L	Whistle	—	You should stop; I have something important to communicate	International Code of Signals
— — — O	Whistle	—	Man overboard	International Code of Signals
· — — · P	Whistle	—	Your lights are out or burning badly	International Code of Signals
· — · R	Whistle	—	The way is off my ship; you may feel your way past me	International Code of Signals
· · — U	Whistle	—	You are standing into danger	International Code of Signals
· · · — V	Whistle	—	I require assistance	International Code of Signals
· — — W	Whistle	—	I require medical assistance	International Code of Signals

APPENDIXES

APPENDIX I

Formulae and Data

When confronted with the problem of deciding what size of rope, chain, shackle or ring and what type of tackle or block should be used for a particular job, the seaman can apply the rough formulae given below, provided that the gear is not liable to be stressed to its safe limits; but if it is so liable, the stresses must be calculated accurately (if necessary, solving polygons or triangles of forces) and the rope tables must be used.

Every item used in rigging has a ***breaking strength***, from which a ***safe working load*** may be found by dividing it by a ***factor of safety*** for the function of the gear.

The following abbreviations will be used in this Appendix:

B.S.—breaking strength (breaking load)
P.L.—proof load
S.W.L.—safe working load
F.S.—factor of safety
C—circumference, in inches
D or *d*—diameter, in inches.

1. FACTORS OF SAFETY

General factors for lifting appliances

Lifts and hoists: 12
Running rigging, slings and tackles: 8
Cranes, shackles, rings of boats' slings and general purposes: 6
Slings in commercial use: 5 or 6
Hooks of boats' slings: $5\frac{1}{2}$
Eyeplates: 4
Pickets: 3.

Minimum factors for wire rope when used with extempore derricks, sheers, gyns and ropeways

Slings and main tackle falls: 8
Lashings and strops: 5
Jackstays and guys: 4

2. CORDAGE

a. NATURAL FIBRE ROPE

Approximate formula

$$\text{B.S.} = \frac{C^2}{3} \text{ tons}$$

More accurate formulae

Ropes of 6-in. and under: $\text{B.S.} = \frac{C^2}{2\cdot 5} \text{ tons}$

Ropes of over 6-in.: $\text{B.S.} = \frac{C^2}{2\cdot 6} \text{ tons}$

General purposes: $\text{S.W.L.} = \frac{\text{B.S.}}{6}$

Weight of a fathom: $0\cdot 19C^2$ lb

Weight of a coil of rope:

manila or sisal $\frac{C^2}{5}$ cwt

coir $\frac{C^2}{9}$ cwt

NATURAL FIBRE CORDAGE TABLES

SIZES, WEIGHTS AND BREAKING STRENGTHS

Notes

1. The breaking strengths given in the tables on pages 589 and 590 are taken from the Navy Department specifications to manufacturers and are correct for *new rope.*

2. New rope may be found to exceed its specified size by an amount allowed to manufacturers. For example, 8-in. manila has a maximum tolerance of $\frac{5}{8}$ in.

NATURAL FIBRE CORDAGE

Sizes, Weights, Breaking Loads and Yarns per Strand

SIZE		GRADE 2 MANILA AND SISAL ROPE, 120 FATHOMS, 3-STRAND, HAWSER-LAID						COIR ROPE, 120 FATHOMS, 3-STRAND, HAWSER-LAID						
Circ.	Diam.	Weight per coil			Minimum breaking load		Yarns per strand	Weight per coil			Minimum breaking load		Yarns per strand	
in.	in.	cwt	qr	lb	ton	cwt	min.	cwt	qr	lb	ton	cwt	min.	max.
5/8	3/16			10		3 1/2	2							
7/8	1/4			17		6 1/2	2							
1	5/16			26		9 1/2	3							
1 1/2	1/2		1	23		18 3/4	6			27		4	2	3
2	5/8		3	9	1	15 1/2	11		1	20		7	3	5
2 1/2	13/16	1	1	4	2	16 1/2	17		2	19		11	5	8
3	1	1	3	7	4	0	24		3	24		15	7	11
3 1/2	1 1/8	2	1	27	5	6 1/2	33	1	1	7	1	0	10	15
4	1 5/16	3	1	0	6	16 1/2	43	1	2	24	1	7	12	20
4 1/2	1 7/16	4	0	9	8	10	54	2	0	19	1	14	16	25
5	1 5/8	5	0	6	10	7	67	2	2	20	2	2	20	32
6	1 15/16	7	1	0	14	12	96	3	3	12	3	0	28	44
7	2 1/4	9	3	16	19	12	131	5	1	0	4	0	38	60
8	2 1/2	12	3	18	25	4	171	6	3	12	5	5	50	80
10	3 1/4	20	0	18	38	12	267	10	2	24	8	2	78	128
12	3 3/4	29	0	0	55	0	384	15	1	20	11	14	112	176
15	4 3/4	45	1	7	85	0	600	24	0	12	18	2	175	276
16	5 1/8													
18	5 5/8													
20	6 3/8													

SISAL BOLTROPE AND STAGE LASHING, 120 FATHOMS, 3-STRAND, HAWSER-LAID						SIZE
Weight per coil			Minimum breaking load		Yarns per strand	Circ.
cwt	qr	lb	ton	cwt	min.	in.
		10		3	2	5/8
						7/8
		25		9	3	1
	1	21		18	6	1 1/2
	3	5	1	15	11	2
1	0	26	2	16	17	2 1/2
1	2	26	4	0	24	3

GRADE 2 MANILA CABLE-LAID ROPE, 9-STRAND, 100 FATHOMS						SIZE
Weight per coil			Minimum breaking load		Yarns per strand	Circ.
cwt	qr	lb	ton	cwt	min.	in.
5	1	4	9	0	24	6
						7
9	1	23	15	19	43	8
14	2	26	22	8	67	10
21	0	13	31	10	96	12
33	0	0	48	5	150	15
37	2	12	54	15	171	16
47	2	2	68	10	216	18
58	2	25	84	0	267	20

SMALL STUFF

Type	Runnage	Minimum Breaking Load	Ply/Strands	Threads (min.)	How supplied
	yd/lb	*lb*			
Flax Twines					
Roping	380	50	3	—	¼ lb cops
Seaming, coarse	525	45	2	—	¼ lb cops
Seaming, medium	700	38	2	—	¼ lb cops
Seaming, fine	1,120	26	2	—	¼ lb cops
Seaming, extra fine	1,200	22	2	—	¼ lb cops
Hemp Twines					
Roping	380	50	3	—	¼ lb cops
Packing, medium	135	100	3	—	¼ lb cops
Marline	60	280	2	—	1 lb skein
Seine	340	50	3	—	¼ lb cops
Upholsterer's, fine	870	25	3	—	¼ lb ball
Upholsterer's, medium	350	50	3	—	¼ lb ball
Hemp Lines, Hawser-Laid					
¾ lb	53	210	3	6	Hanks of 40 yd, the weights of which designate the line
2 lb	20	580	3	12	
3 lb	13	810	3	15	
4 lb	10	1,035	3	21	
Hemp Fishing Line					
Whiting (2 oz)		48	3	6	Hank of 40 yd
Mackerel (large) (¾ lb)		140	3	6	Hank of 60 yd
Codfish (2¼ lb)		320	3	9	Hank of 80 yd
Hemp, Miscellaneous					
Indicator (5 oz)		100	3	12	Hank of 40 yd
Spunyarn					Pads or coils of 56 lb
Nettlestuff					Pads or coils of 14 lb

b. MAN-MADE FIBRE ROPE

Approximate formulae

NYLON

Under 4-inch: B.S. $= C^2$ tons

4-inch and over: B.S. $= 0{\cdot}9C^2$ tons

Weight of 120-fathom coil

size of rope (*inches*):	1	2	3	4	5	6	7	8	9	10
weight (*cwt*):	$\frac{1}{4}$	$\frac{3}{4}$	$1\frac{3}{4}$	3	$4\frac{3}{4}$	7	$9\frac{1}{2}$	$12\frac{1}{4}$	$15\frac{1}{2}$	$19\frac{1}{4}$

TERYLENE

Under 4-inch: B.S. $= 0{\cdot}8C^2$ tons

4-inch and over: B.S. $= \dfrac{3C^2}{4}$ tons

Weight of 120-fathom coil

size of rope (*inches*):	1	2	3	4	5	6	7	8	9	10
weight (*cwt*):	$\frac{1}{4}$	1	2	$3\frac{1}{2}$	$5\frac{1}{2}$	8	$10\frac{3}{4}$	$14\frac{1}{4}$	18	22

For tables, see overleaf.

MAN-MADE CORDAGE TABLES

SIZES, WEIGHTS AND BREAKING STRENGTHS

NYLON ROPE

Nominal Circumference	Approximate Diameter	Weight per 10 fathoms	Breaking Strength	
in.	*in.*	*lb*	*tons*	*cwt*
5/8	3/16	0·71	—	7·80
3/4	7/32	1·05	—	11·16
7/8	1/4	1·38	—	15·17
1	5/16	1·80	1	—
1 1/8	11/32	2·40	1	5·00
1 1/4	3/8	2·82	1	11·25
1 3/8	7/16	3·42	1	17·50
1 1/2	1/2	3·96	2	4·64
1 5/8	17/32	4·80	2	13·57
1 3/4	9/16	5·52	3	2·50
2	5/8	7·20	4	—
2 1/4	3/4	9·00	5	—
2 1/2	13/16	11·40	6	5
2 3/4	7/8	13·80	7	10
3	1	16·20	9	—
3 1/4	1 1/16	19·20	10	10
3 1/2	1 1/8	22·20	12	—
3 3/4	1 1/4	25·20	13	10
4	1 5/16	28·80	15	10
4 1/2	1 7/16	36·60	19	—
5	1 5/8	45·00	23	10
5 1/2	1 3/4	54·60	28	—
6	1 15/16	64·80	33	—
6 1/2	2 1/8	76·20	38	10
7	2 1/4	88·00	44	—
7 1/2	2 3/8	101·40	50	—
8	2 1/2	115·00	57	—
9	2 7/8	145·50	71	—
10	3 1/4	179·70	87	—

TERYLENE ROPE

Nominal Circumference	Approximate Diameter	Weight per 10 fathoms	Breaking Strength	
in.	*in.*	*lb*	*tons*	*cwt*
5/8	3/16	0·81	—	7·14
3/4	7/32	1·21	—	9·82
7/8	1/4	1·58	—	12·94
1	5/16	2·17	—	16·51
1 1/8	11/32	2·63	1	0·98
1 1/4	3/8	3·25	1	5·40
1 3/8	7/16	3·90	1	10·35
1 1/2	1/2	4·68	1	16·1
1 5/8	17/32	5·40	2	2·85
1 3/4	9/16	6·33	2	10
2	5/8	8·25	3	6·51
2 1/4	3/4	10·50	4	5
2 1/2	13/16	12·91	5	5
2 3/4	7/8	15·60	6	5
3	1	18·60	7	10
3 1/4	1 1/16	21·80	8	15
3 1/2	1 1/8	25·30	10	—
3 3/4	1 1/4	28·80	11	10
4	1 5/16	33·00	12	15
4 1/2	1 7/16	41·80	16	—
5	1 5/8	51·60	19	10
5 1/2	1 3/4	62·50	23	5
6	1 15/16	74·40	27	10
6 1/2	2 1/8	87·20	32	—
7	2 1/4	101·20	37	—
7 1/2	2 3/8	116·20	42	—
8	2 1/2	132·00	47	10
9	2 7/8	167·30	59	—
10	3 1/4	206·40	72	—

3. WIRE ROPE

Approximate formulae

F.S.W.R. of $4\frac{1}{2}$ inch and under: B.S. $= 2C^2$ tons
F.S.W.R. of over $4\frac{1}{2}$ inch: B.S. $= 2{\cdot}5C^2$ tons
S.W.R.: B.S. $= 2{\cdot}75C^2$ tons
E.S.F.S.W.R.: B.S. $= 3{\cdot}6C^2$ tons
Weight of a fathom (S.W.R. and E.S.F.S.W.R.): $= C^2$ lb
Least diameter of a sheave: $6C$
Least diameter of a bollard: $4C$

LASHING OR STROP

The breaking strength is $\frac{9nC^2}{20}$ tons, where n is the number of turns in the lashing or half the number of parts in the strop. This includes an allowance for bad nips and unequal distribution of stress in the parts.

GROMMET STROPS

Three- and four-parted strops are usually doubled when joining hawsers together, but the five- and six-parted strops are seldom doubled.

The approximate breaking strength of all grommet strops can be calculated from:

$$\text{B.S.} = f\frac{C^2 n}{10} \text{ tons, where}$$

C is the circumference of the rope from which the strand is taken;
f is the factor for the different types of wire, e.g. $2{\cdot}5$ for F.S.W.R.;
n is the *total* number of strands of the strop, i.e. 16 strands for a four-parted strop used doubled.

EXAMPLE

What is the breaking strength of a four-parted grommet strop constructed from 3-inch F.S.W.R. and used doubled to join two hawsers?

$$\text{B.S.} = \frac{2 \times 9 \times 16}{10} = 28{\cdot}8 \text{ tons}$$

But wire is constructed with varying numbers of strands, and the breaking strengths vary with the construction. The tables of wire rope on the opposite page give details of construction, compare flexibility and also give the minimum diameter of sheave acceptable for each type.

WIRE ROPE TABLES

Type, Construction, Flexibility, Minimum Diameter of Sheave and Breaking Strength Formulae

Type	Construction of Rope	Construction of Strands	Heart of Rope	Core of Strands	Degree of Flexibility	Minimum Diameter of Sheave	Approximate Breaking Strength (in tons)
E.S.F.S.W.R.	6 × 61	24/18/12/6/1	Hemp	Wire	Extra flexible	5·8C	3·3C^2
E.S.F.S.W.R.	6 × 37	18/12/6/1	Hemp	Wire	Very flexible	6·3C	3·6C^2
F.S.W.R.	6 × 12	12/Jute	Hemp or jute	Jute			2·1C^2
F.S.W.R.	6 × 30	18/12/Jute	Hemp	Jute	Flexible	6·5C	2·7C^2
E.S.F.S.W.R.	6 × 24	15/9/Jute	Jute	Jute	Less flexible than 6 × 30	7C	3·6C^2
F.S.W.R.	6 × 24	15/9/Jute	Jute	Jute			2·7C^2
E.S.F.S.W.R.	6 × 19	12/6/1	Jute	Wire	Less flexible than 6 × 24	8·5C	3·6C^2
S.W.R.	6 × 19	12/6/1	Hemp	Wire			2·8C^2
S.W.R.	6 × 7	6/1	Hemp	Jute	Least flexible	Not applicable	2·9C^2

WIRE ROPE

Type	Size (nominal circum).	Construction	Length of Coil	Weight per fathom	Minimum Breaking Load
	in.		*fm*	*lb*	*tons*
Steel Wire Rope for standing rigging	¾	6 × 7	200	0·540	1·60
	1	6 × 7	200	1·080	3·20
	1½	6 × 7	200	2·160	6·25
	2	6 × 7	200	3·960	11·50
	2½	6 × 7	200	6·120	17·75
	3	6 × 7	200	8·700	26·00
	3½	6 × 7	150	11·880	35·00
	4	6 × 19	150	15·780	49·50
Flexible Steel Wire Rope for hawsers and running rigging	1	6 × 12	300	0·750	2·25
	1¼	6 × 12	300	1·080	3·25
	1½	6 × 12	300	1·500	4·80
	1¾	6 × 12	300	2·100	6·25
	2	6 × 12	300	2·750	8·50
	2½	6 × 12	360	4·200	13·20
	2½	6 × 24	250	5·700	18·00
	3	6 × 12	360	6·000	18·75
	3½	6 × 12	360	8·400	25·70
	4	6 × 12	360	10·980	33·50
	4	6 × 24	—	14·340	45·00
	4½	6 × 12	150	14·040	43·50
	5	6 × 24	150	22·680	68.90
	5½	6 × 24	150	27·000	82·00
	6	6 × 30	150	31·020	97·50
	6½	6 × 30	150	35·220	110·00
Extra Special Flexible Steel Wire Rope for hoists and other special purposes	⅜	6 × 19	100	0·135	0·50
	½	6 × 19	100	0·230	0·90
	⅝	6 × 19	100	0·350	1·40
	¾	6 × 19	250	0·510	2·05
	⅞	6 × 24	100	0·680	2·75
	1	6 × 24	300	0·960	3·60
	1⅛	6 × 24	300	1·120	4·40
	1¼	6 × 37	300	1·400	5·75
	1⅜	6 × 37	300	1·700	7·00
	1½	6 × 37	300	2·100	8·25
	1¾	6 × 37	300	2·900	11·25
	1⅞	6 × 37	300	3·500	12·80
	2	6 × 37	300	3·900	14·70
	2¼	6 × 37	300	4·800	18·30
	2½	6 × 37	300	5·900	22·75
	2¾	6 × 37	300	7·300	27·50
	3	6 × 37	150	8·700	33·00
	3¼	6 × 37	150	10·300	39·00
	3½	6 × 37	150	12·000	45·00
	4	6 × 37	150/230/500/550	15·300	58·00
	4½	6 × 37	150/250/300/550	19·100	73·00
	5	6 × 37	150/250/350	23·500	90·00
	5½	6 × 37	150	29·600	108·00
	6½	6 × 37	150	40·900	151·40
	7	6 × 61	—	47·900	161·00
	9	6 × 37	—	79·200	238·80
	9	6 × 61	—	79·200	267·30
	9	6 × 91	—	79·200	245·90

Type	Size (nominal circum).	Construction	Length of Coil	Weight per fathom	Minimum Breaking Load
	in.		*fm*	*lb*	*tons*
Steel Wire Rope for lifts (Lang's lay)	$\frac{3}{4}$	6 × 19	300	0·540	1·60
	1	6 × 19	300	1·080	2·90
	$1\frac{1}{4}$	6 × 19	300	1·500	4·50
	$1\frac{1}{2}$	6 × 19	300	2·160	6·40
	$1\frac{3}{4}$	6 × 19	300	3·000	8·60
Extra Special Flexible Steel Wire Rope (Lang's lay) for topping lifts for aircraft, boat and deck cranes	$1\frac{7}{8}$	6 × 37	150	3·500	12·80
	2	6 × 37	150	3·900	14·70
	$2\frac{1}{4}$	6 × 37	150	4·800	18·30
	$2\frac{1}{2}$	6 × 37	150	5·900	22·75
	$2\frac{3}{4}$	6 × 37	150	7·300	27·50
	$2\frac{7}{8}$	6 × 37	150	8·000	30·30
	3	6 × 37	150	8·700	33·00
	$3\frac{1}{4}$	6 × 37	150	10·300	39·00
	$3\frac{1}{2}$	6 × 37	150	12·000	45·00
Flexible Steel Wire Rope for boat's rigging	$\frac{3}{8}$	5 × 7	100	0·145	0·45
	$\frac{3}{4}$	6 × 12	300	0·420	1·00
Mine-mooring ropes and non-serrated sweeping rope	$1\frac{1}{4}$	7 × 7	450	1·600	6·70
Flexible Steel Wire Rope for lacings, etc.	$\frac{7}{8}$	6 × 12	100	0·550	1·75
Flexible Mild Steel Wire Rope and strand for seizings	$\frac{5}{16}$	1 × 6	100	0·120	0·10
	$\frac{3}{8}$	1 × 10	100	0·144	0·16
	$\frac{3}{4}$	4 × 6	100	0·50	0·40
	$1\frac{1}{4}$	4 × 16	100	1·31	1·05
					cwt
Flexible Mild Steel Rope and strand for fitting catch nets	$\frac{3}{16}$	1 × 7	100	0·045	0·803
Best plough-steel wire strand for sounding machines		1 × 7	300	0·207	4·45

JACKSTAYS WHEN USED AS ROPEWAYS

The theoretical tension in a jackstay, between supports at the same level, is:

$$T = \frac{Wl}{4d}$$

where

W is the total weight of the load, including traveller and slings,
l is the distance between supports,
d is the dip of the centre of the jackstay (in same units as l).

If d is expressed in terms of l, then:

$$\text{when } d = \frac{l}{20},\ T = 5W$$

$$\text{when } d = \frac{l}{10},\ T = \frac{5W}{2}$$

This formula does not take into account the weight of the jackstay, which must be considered when the jackstay is long and the load heavy. In the table below the weight of jackstay, where appreciable, has been taken into account. The table is based on a factor of safety of 4: the dip is one-twentieth of the length when the load is at the centre, and the difference in level of the supports should not be more than one twenty-fifth of its length. The load must include the weight of the slings and traveller, and an allowance of 10 per cent must be made for impact loading and wind.

Size of F.S.W.R.	Tension in Jackstay	Total Load on Jackstays of			
		200 ft	300 ft	400 ft	500 ft
in.	*ton*	*cwt*	*cwt*	*cwt*	*cwt*
1	0·5	2	1·9	1·8	1·6
1½	1·0	4	3·8	3·6	3·2
2	2·8	10	9·5	6·0	8·0
2½	4·2	16	15·2	14·4	12·8
3	6·4	22	20·9	19·8	17·6

4. SAFE WORKING LOADS

COMMON FITTINGS

Fitting	S.W.L. (tons)	Where d is measured	Remarks (*D is internal diameter.*)
Chain (rigging)			
ordinary	$6d^2$	on the smallest link	P.L. is $12d^2$; B.S. is $27d^2$
short link	$6d^2$		
Eyebolts (screwed)	$3d^2$	the metal of the eye	
Eyeplates	$6d^2$	the metal of the eye	
Hooks	$\frac{d^2}{2}$	at the back of the hook	provided that $\frac{D}{d}$ is less than 2·5
Ringbolts	$2d^2$	the metal of the ring	
Rings			
common	$2d^2$	the metal of the ring	$\frac{D}{d} = 4$ (used in R.N.)
others	$\frac{7d^3}{D}$ (approx.)	the metal of the ring	$\frac{D}{d}$ is greater than 2·3
Shackles (rigging)			
straight	$4d^2$	at the crown	
bow	$2{\cdot}5d^2$	at the crown	
Slips (rigging)	$5d^2$ (approx.)	on the link of the slip	

CHAIN CABLE

Chain cable is tested to a proof load which is about two-thirds of the breaking strength.

Approximate formulae

Forged steel up to, and including, 2½ in. P.L. $= 25d^2$ tons (approx.)
B.S. $= 38d^2$ tons (approx.)

Wrought iron up to, and including, 2½ in. P.L. $= 18d^2$ tons
B.S. $= 27d^2$ tons

Forged steel and wrought iron over 2½ in. 5 per cent reduction for every ½ in. over 2½ in.

Weight of one fathom of cable $= \frac{d^2}{40}$ tons

Stowage space required for 100 fathoms $= 35d^2$ cu. ft

Diameter of hawsepipe $= 12d$ inches

Diameter of navel pipe $= 8d$ inches

SLIPS AND CLENCHES

Cable clench is tested to 20 per cent above the P.L. of the cable.

Blake slips and screw slips are tested to one-half P.L. of the cable.

Clenches for Blake and screw slips are tested to 20 per cent more than their slips.

BLOCKS FOR CORDAGE

An ordinary wooden block will take a rope one-third of its size.

A clump block will take a rope half its size. Its strength is approximately one-quarter of the strength of an ordinary block used for the same size of rope.

A snatch block will take a rope one-third of its size. Its strength is about two-thirds of the strength of an ordinary block used for the same size of rope.

THIMBLES

The size of rope which a thimble will take depends on both the width and depth of the score, but for practical purposes the sizes are as follows:

Wire rope: $3d$

Served wire rope: $2 \cdot 5d$

Fibre rope: $2 \cdot 75d$

where d is the width of the score.

They have no specified working load, but a steel thimble should not be distorted by a pull of $\frac{L^2}{2}$ tons, where L is the length of the thimble in inches, and it will usually crush at about $\frac{3L^2}{4}$ tons. Iron thimbles are not so strong as steel, but they are adequate for natural fibre rope.

NETS

S.W.L. of a wire cargo net is 3 tons.

S.W.L. of a cordage cargo net is 1·5 tons.

PURCHASES AND TACKLES

The pull required on the hauling part of a tackle can be calculated from the formula:

$$P = \frac{W}{V}\left(1 + \frac{n}{10}\right),$$

where P is the pull on the hauling part,

W is the weight to be hoisted,

V is the velocity ratio,

n is the number of sheaves in the system, and the loss from friction is one-tenth for every sheave.

If the mechanical advantage of the tackle is known, then the pull can be calculated more simply by dividing the weight by the mechanical advantage, i.e.

$$P = \frac{W}{M.A.};$$

therefore $M.A. = \frac{W}{P}$, or $W = P \times M.A.$

Since blocks are always stronger than the ropes for which they are designed, the maximum working load of a purchase depends on the strength of the rope.

The following table gives the velocity ratio, mechanical advantage and safe working load factor for certain factors of safety of some of the common tackles. The mechanical advantage is calculated from the formula $M = \frac{10V}{10+n}$, where n is the number of sheaves and the loss from friction is one-tenth for each sheave.

Tackle	F.S.	Rove to advantage			Rove to disadvantage		
		V	M.A.	S.W.L. (tons)	V	M.A.	S.W.L. (tons)
Single whip	12				1	0·90	$\frac{C^2}{33}$
Double whip	12				2	1·67	$\frac{C^2}{18}$
Gun tackle	8	3	2·50	$\frac{C^2}{8}$			
Luff	8	4	3·08	$\frac{2C^2}{13}$	3	2·30	$\frac{C^2}{9}$
Two-fold purchase	8	5	3·57	$\frac{2C^2}{11}$	4	2·86	$\frac{C^2}{7}$
Treble and double block	8				5	3·33	$\frac{C^2}{6}$
Three-fold purchase	8	7	4·37	$\frac{7C^2}{32}$	6	3·75	$\frac{3C^2}{16}$

Examples

1. *What size of rope will be required in a two-fold purchase, rove to disadvantage, to hoist a load of 3·5 tons?*

From the table S.W.L. $= \frac{C^2}{7} = 3{\cdot}5$

$\therefore\ C^2 = 24{\cdot}5$

$C = 5$ inches

2. *A whaler weighs 48 cwt. If both falls are treble and double blocks rove to disadvantage, what size of rope is required?*

S.W.L. $= 24$ cwt $\left(\frac{6}{5}\text{ tons}\right)$ for each fall

$$\therefore\ \frac{C^2}{6} = \frac{6}{5}$$

$$C^2 = \frac{36}{5}$$

$C = 2\frac{3}{4}$ inches (approx.)

If each man on a fall can exert a pull of $\frac{1}{2}$ cwt, how many men will be required to hoist the boat?

The pull required on each fall $= \frac{W}{M.A.} = \frac{24}{3{\cdot}33} = 7{\cdot}2$ cwt

The number of men required on each fall $= 7{\cdot}2 \times 2 = 15$ (approx.)

Total number of men required $= 30$.

3. *It is required to lift a load of 4·4 tons. What purchase should be used, what size of rope, and what will be the pull?*

If a three-fold purchase is used rove to disadvantage,

$$\frac{3C^2}{16} = 4{\cdot}4$$

$$C^2 = \frac{4{\cdot}4 \times 16}{3}$$

$C = 5$ inches (approx.); therefore no smaller purchase should be considered.

The pull $P = \frac{W}{M.A.} = \frac{4{\cdot}4}{3{\cdot}75} = 1{\cdot}2$ tons (approx.)

4. *What load can be hoisted by a luff rove with 2-inch cordage to advantage?*

S.W.L. $= \frac{2C^2}{13} = \frac{8}{13}$ tons $= 12$ cwt (approx.)

Special purchases

If the loss due to friction is less than one-tenth for each sheave of the purchase, the formula for finding the pull on the hauling part must be amended. For example, when the loss is one-twentieth,

$$P = \frac{W}{V}\left(1 + \frac{n}{20}\right)$$

HAND WINCHES

A hand winch is designated by the maximum pull which can be applied by it, the winches usually provided being of 1, 3, 5, 8 and 10 tons capacity; in practice, however, only about seven-tenths of its maximum pull can be applied by the men working a winch. The winch is provided with a crank handle on each side, and they should be shipped at an angle of 90 degrees to each other to avoid dead-centres; the number of men who can work on each handle varies from two to four, depending on the size of winch. To prevent a winch up-ending when under load it must be bolted to wooden bearers, which should project far enough in front of the winch to ensure that the up-ending moment is balanced by the weight of the winch on the rear end of the bearers. The bearers themselves should be braced together and secured from moving by pickets driven in in front of them, and their rear ends should be secured to a holdfast. The following formula gives the length of the bearers required for a particular pull on the winch-rope:

$$L = \frac{PH}{W},$$

where:

L is the minimum distance in feet from the forward end of the bearer to the centre of the winch,

P is the pull in the winch-rope,

H is the height in feet of the bottom of the drum above the bearer,

W is the weight of the winch in the same units as P.

The weight of a winch can be taken roughly as being one-third of its maximum pull.

The winch-rope must be led on to the bottom of the drum to reduce its up-ending moment to a minimum.

The rope capacity of a winch drum is given by the following formula:

$$L = \frac{2{\cdot}5\, bf(f + d)}{c^2},$$

where:

L is the length of the winch-rope in feet,

b is the length of the drum in inches,

d is the diameter of the drum in inches,

f is the depth of the flange of the drum in inches,

c is the circumference of the rope in inches.

5. TIMBER

Selected timber is grouped according to the compressive strength of the wood.

Group I timber includes oak, teak and Douglas fir. It is used for masts and derricks in ships (if of wood) and for shoes of extempore derricks. It is about one-fifth stronger than Group II.

Group II timber includes European redwood, European whitewood and elm. It is used for the spars of extempore sheers, derricks and gyns. It is about one-fifth stronger than Group III.

Group III timber is unreliable and is used only for planks and skidding.

SPARS FOR DERRICKS, SHEERS AND GYNS

(Selected timber of Group II)

The table below gives the safe working thrust on spars of various sizes and lengths. The table is based on the formula:

$$P = \frac{2{\cdot}16\, d^2}{1 + \frac{16}{750}\left(\frac{l}{d}\right)^2},$$

where:

P is the buckling load in tons,

l is the length of the spar in inches,

d is the mean diameter of the spar in inches.

A factor of safety of 10 has been used in the table.

Mean diameter (inches)	Length (ft)									Size of equivalent square baulk (inches)
	10	15	20	25	30	35	40	45	50	
6	0·81	0·43	0·22	0·14	0·10	—	—	—	—	5·0
7	1·45	0·91	0·40	0·26	0·18	0·13	0·10	—	—	5·8
8	2·38	1·17	0·62	0·44	0·31	0·23	0·18	0·14	0·11	6·7
9	3·6	1·83	1·07	0·71	0·50	0·35	0·28	0·22	0·18	7·5
10	5·3	2·7	1·63	1·07	0·75	0·56	0·43	0·34	0·28	8·3
11	7·4	3·8	2·34	1·54	1·10	0·81	0·62	0·50	0·40	9·2
12	9·9	5·6	3·25	2·17	1·54	1·14	0·88	0·70	0·57	10·0
13	12·9	6·6	4·4	2·95	2·10	1·57	1·21	1·00	0·78	10·8
14	16·5	9·4	6·2	3·9	2·8	2·10	1·62	1·29	1·05	11·7
15	20·5	11·9	7·5	5·1	3·6	2·7	2·12	1·69	1·38	12·5

WEIGHT OF TIMBER

The weight per cubic foot gives an approximate indication of a timber's strength, and generally the greater the weight the stronger the timber.

Type of timber	Weight per cu. ft (at dry air condition 15 to 18% m.c.)	Type of timber	Weight per cu. ft (at dry air condition 15 to 18% m.c.)
	lb		*lb*
Ash and beech	45	Softwood	
		Douglas fir	33
Elm		European redwood	33
Canadian rock	51	Larch, European	37
English	43	Pitch pine	41
		Scotch pine	33
Greenheart	65	Spruce, Canadian	28
		,, Sitka	28
Oak		Western white pine	28
American white	48	Yellow pine	26
American red	53		
English	47		
Teak			
Burmese	41		
Indian	41		

BAULKS FOR HOLDFASTS

The safe working load of a selected baulk of timber can be found from the formula:

$$W = \frac{Kbd^2}{l},$$

where:

W is the breaking load in cwt,
l is the length between supports in feet,
d is the depth of baulk (measured parallel with pull) in inches,
b is the breadth of baulk in inches,
K is a constant for the type of timber used.

Typical figures for K are:

Elm and fir: 3·5
Oak: 4·5
Pitch pine: 5·0

Use a factor of safety of 5 for the safe load.

HOLDFASTS AND PICKETS

Pickets of ash 5 ft long and 3 in. in diameter driven 3 ft into good ground will hold a safe load of:

singly: 7 cwt
one-and-one combination: 14 cwt
two-and-one combination: 1 ton
three-two-and-one combination: 2 tons
allowing a factor of safety of 3.

Baulk and pickets. Allow a safe holding load of 6 cwt for each picket up to the safe working load of the baulk.

Buried baulk. The table below gives the safe resistance in pounds for each square foot of the face of the baulk when buried in good loam earth.

Mean Depth of Baulk below Surface, in feet	Safe Resistance in lb per sq. ft of Face when Slope of Strop is:			
	One in One	One in Two	One in Three	One in Four
1	110	150	160	175
$1\frac{1}{2}$	250	320	360	390
2	410	580	650	700
3	950	1,300	1,450	1,500
4	1,750	2,200	2,600	2,700
5	2,800	3,600	4,000	4,100
6	3,800	5,100	5,800	6,000
7	5,100	7,000	8,000	8,400

6. BUOYANCY

TIMBER

The safe buoyancy of a spar $B = \frac{9}{10}(VM - VN)$ lb, where:

V is the volume of the spar in cubic feet,

M is the weight of a cubic foot of water (i.e. $62\frac{1}{2}$ lb for fresh water and 64 lb for sea water),

N is the weight of the wood in pounds per cubic foot (see table on page 605).

DRUM

The safe buoyancy $B = 9C$ lb, where C is the capacity of the drum in gallons. If the capacity of the drum is not known, its safe buoyancy can be found from:

$B = 4{\cdot}5c^2 l - W$ lb, where:

c is the circumference of the drum in feet,

l is the length of the drum in feet,

W is the weight of the drum in pounds.

APPENDIX II

Common Rigging Fittings

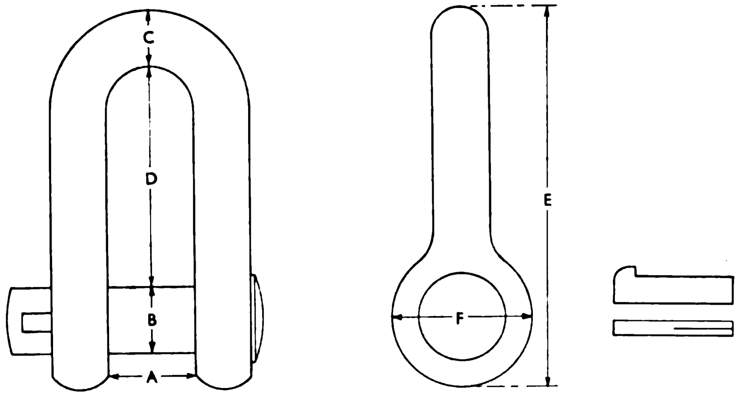

FIG. A–1. Rigging shackles: straight shackle with forelock

B10c Patt. No. 0263/....	5456	5457	5458	5459	5460	5461	5462	5463	5464
Size of shackle	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Proof test (tons)	1/2	1 1/8	2	3 1/8	4 1/2	6 1/8	8	10 1/8	12 1/2
Distance in clear (A)	13/32	5/8	13/16	1	1 7/32	1 13/32	1 5/8	1 13/16	2
Diameter of bolt (B)	3/8	1/2	5/8	3/4	1	1 1/8	1 1/4	1 3/8	1 1/2
Diameter of metal (C)	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Internal length (D)	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5
External length (E)	1 13/16	2 5/8	3 7/16	4 1/4	5 1/4	6 1/16	6 7/8	7 11/16	8 1/2
External diameter of lug (F)	3/4	1	1 1/4	1 1/2	2	2 1/4	2 1/2	2 3/4	3

B10c Patt. No. 0263/....	5465	5466	5467	5468	5469	5470	5471	5472	5473
Size of shackle	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8
Proof test (tons)	15 1/8	18	21 1/8	24 1/2	28 1/8	32	36 1/8	40 1/2	45 1/8
Distance in clear (A)	2 7/32	2 13/32	2 5/8	2 13/16	3	3 7/32	3 13/32	3 5/8	3 13/16
Diameter of bolt (B)	1 3/4	1 7/8	2	2 1/8	2 1/4	2 1/2	2 5/8	2 3/4	2 7/8
Diameter of metal (C)	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/4	2 3/8
Internal length (D)	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2
External length (E)	9 1/2	10 5/16	11 1/8	11 15/16	12 3/4	13 3/4	14 9/16	15 3/8	16 3/16
External diameter of lug (F)	3 1/2	3 3/4	4	4 1/4	4 1/2	5	5 1/4	5 1/2	5 3/4

ALL DIMENSIONS IN INCHES

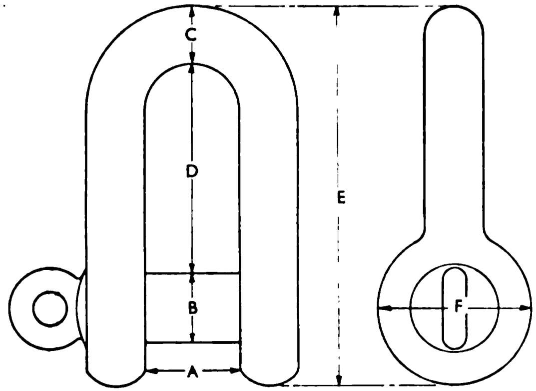

FIG. A–2. Rigging shackles: straight shackle with screw bolt

B10c Patt. No. 0263/....	5440	5441	5442	5443	5444	5445	5446	5447	5448	5449	5450	5451	5452	5453	5454
Size of shackle	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2
Proof test (tons)	$\frac{1}{2}$	$1\frac{1}{8}$	2	$3\frac{1}{8}$	$4\frac{1}{2}$	$6\frac{1}{8}$	8	$10\frac{1}{8}$	$12\frac{1}{2}$	$15\frac{1}{8}$	18	$21\frac{1}{8}$	$24\frac{1}{2}$	$28\frac{1}{8}$	32
Distance in clear (A)	$\frac{13}{32}$	$\frac{5}{8}$	$\frac{13}{16}$	1	$1\frac{7}{32}$	$1\frac{13}{32}$	$1\frac{5}{8}$	$1\frac{13}{16}$	2	$2\frac{7}{32}$	$2\frac{13}{32}$	$2\frac{5}{8}$	$2\frac{13}{16}$	3	$3\frac{7}{32}$
Diameter of bolt (B)	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$
Diameter of metal (C)	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2
Internal length (D)	$\frac{15}{16}$	$1\frac{3}{8}$	$1\frac{13}{16}$	$2\frac{1}{4}$	$2\frac{11}{16}$	$3\frac{3}{16}$	$3\frac{5}{8}$	$4\frac{1}{16}$	$4\frac{1}{2}$	$4\frac{15}{16}$	$5\frac{7}{16}$	$5\frac{7}{8}$	$6\frac{5}{16}$	$6\frac{3}{4}$	$7\frac{3}{16}$
External length (E)	$1\frac{3}{4}$	$2\frac{1}{2}$	$3\frac{1}{4}$	4	$4\frac{15}{16}$	$5\frac{3}{4}$	$6\frac{1}{2}$	$7\frac{1}{4}$	8	$8\frac{15}{16}$	$9\frac{3}{4}$	$10\frac{1}{2}$	$11\frac{1}{4}$	12	$12\frac{15}{16}$
External diameter of lug (F)	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	5

ALL DIMENSIONS IN INCHES

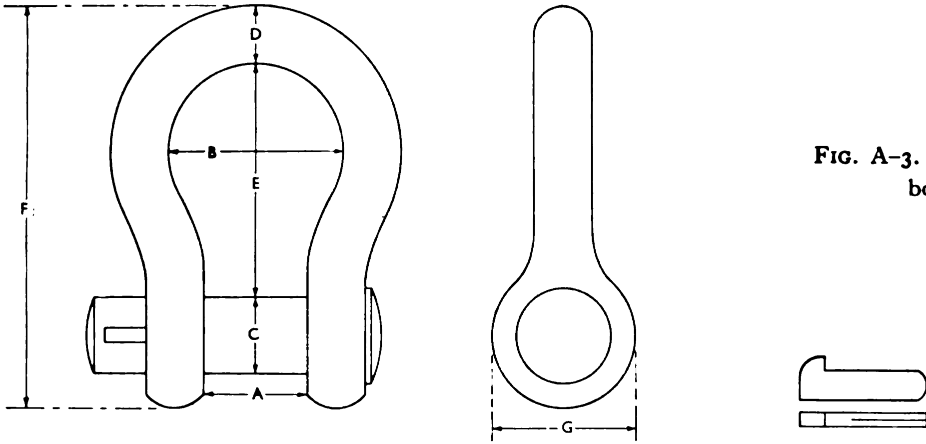

FIG. A-3. Rigging shackles: bow shackle with forelock

B10c Patt. No. 0263/....	5356	5357	5358	5359	5360	5361	5362	5363	5364	5365	5366	5367	5368	5369	5370	5371
Size of shackle	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{2}$
Proof test (tons)	$\frac{1}{4}$	$\frac{5}{8}$	$1\frac{1}{4}$	2	$2\frac{7}{8}$	4	5	$6\frac{3}{8}$	$7\frac{7}{8}$	$9\frac{1}{2}$	$11\frac{1}{4}$	$13\frac{1}{4}$	$15\frac{3}{8}$	$17\frac{3}{8}$	20	$31\frac{1}{4}$
Distance in clear (A)	$\frac{1}{2}$	$\frac{11}{16}$	$\frac{13}{16}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{8}$	$1\frac{13}{16}$	$2\frac{1}{16}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{13}{16}$	$3\frac{3}{16}$	$3\frac{3}{8}$	$3\frac{5}{8}$	$4\frac{1}{2}$
Distance at (B)	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{1}{4}$	$2\frac{5}{8}$	3	$3\frac{3}{8}$	$3\frac{3}{4}$	$4\frac{1}{8}$	$4\frac{1}{2}$	$4\frac{7}{8}$	$5\frac{1}{4}$	$5\frac{5}{8}$	6	$7\frac{1}{2}$
Diameter of bolt (C)	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$	3
Diameter of metal (D)	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{2}$
Internal length (E)	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	10
External length (F)	$1\frac{13}{16}$	$2\frac{5}{8}$	$3\frac{7}{16}$	$4\frac{1}{4}$	$5\frac{1}{4}$	$6\frac{1}{16}$	$6\frac{7}{8}$	$7\frac{11}{16}$	$8\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{5}{16}$	$11\frac{1}{8}$	$11\frac{15}{16}$	$12\frac{3}{4}$	$13\frac{3}{4}$	17
External diameter of lug (G)	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	5	6

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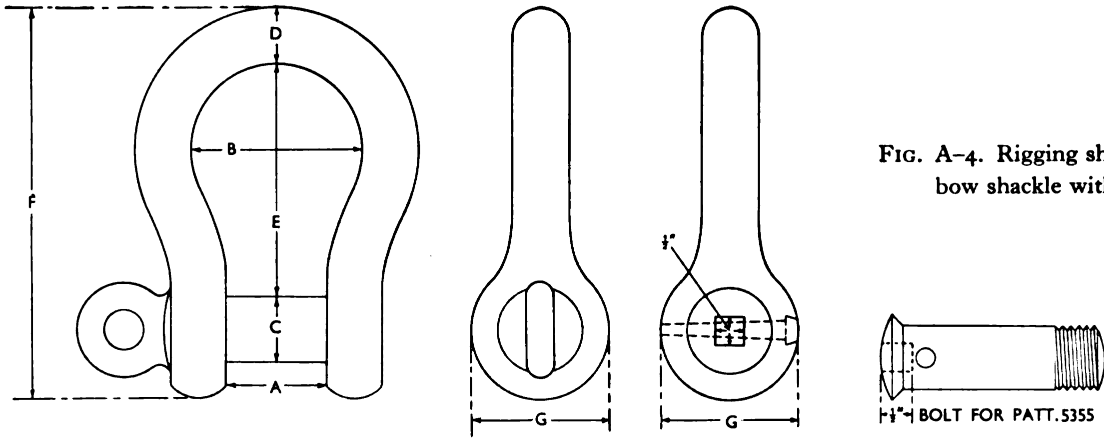
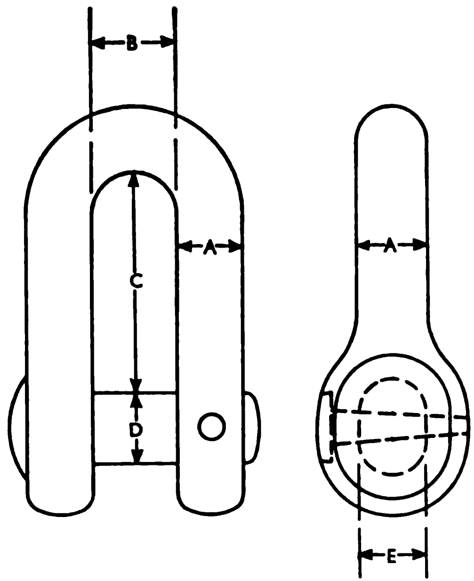


FIG. A-4. Rigging shackles: bow shackle with screw bolt

B10c Patt. No. 0263/....	5340	5341	5342	5343	5344	5345	5346	5347	5348	5349	5350	5351	5352	5353	5354	5355
Size of shackle	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	1
Proof test (tons)	1/4	5/8	1 1/4	2	2 7/8	4	5	6 3/8	7 7/8	9 1/2	11 1/4	13 1/4	15 3/8	17 5/8	20	5
Distance in clear (A)	1/2	11/16	15/16	1 1/8	1 3/8	1 5/8	1 13/16	2 1/16	2 1/4	2 1/2	2 3/4	2 15/16	3 3/16	3 3/8	3 5/8	1 13/16
Distance at (B)	3/4	1 1/8	1 1/2	1 7/8	2 1/4	2 5/8	3	3 3/8	3 3/4	4 1/8	4 1/2	4 7/8	5 1/4	5 5/8	6	3
Diameter of bolt (C)	3/8	1/2	5/8	3/4	1	1 1/8	1 1/4	1 3/8	1 1/2	1 3/4	1 7/8	2	2 1/8	2 1/4	2 1/2	1 1/4
Diameter of metal (D)	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	1
Internal length (E)	1	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	4
External length (F)	1 13/16	2 5/8	3 7/16	4 1/4	5 1/4	6 1/16	6 7/8	7 11/16	8 1/2	9 1/2	10 5/16	11 1/8	11 15/16	12 3/4	13 3/4	6 7/8
External diameter of lug (G)	3/4	1	1 1/4	1 1/2	2	2 1/4	2 1/2	2 3/4	3	3 1/2	3 3/4	4	4 1/4	4 1/2	5	2 1/2

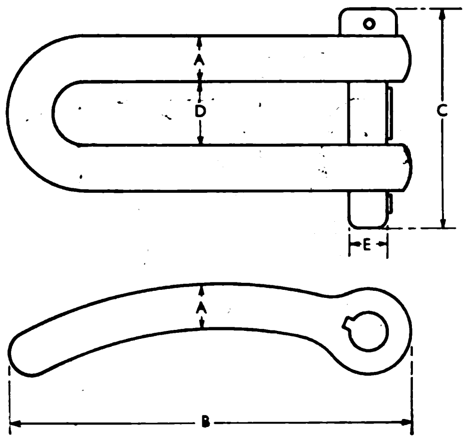
ALL DIMENSIONS IN INCHES



B4b Patt. No.	Proof Test (tons)	Dimensions					Appropt. size of Hawser	Appropt. size of Slip
		A	B	C	D	E		
1941	15	$1\frac{3}{8}$	2	$5\frac{3}{4}$	$1\frac{7}{8}$	$1\frac{1}{8}$	$2-2\frac{1}{4}$	$1\frac{1}{16}-1\frac{1}{4}$
1942	20	$1\frac{5}{8}$	$2\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{1}{8}$	$1\frac{3}{8}$	$2\frac{1}{4}-3$	$1\frac{1}{4}-1\frac{3}{8}$
1943	30	$1\frac{7}{8}$	$2\frac{3}{4}$	$8\frac{1}{8}$	$2\frac{3}{4}$	$1\frac{5}{8}$	$3-3\frac{1}{2}$	$1\frac{7}{16}-1\frac{5}{8}$
1944	40	$2\frac{1}{4}$	3	9	$3\frac{1}{8}$	$1\frac{7}{8}$	$3\frac{1}{2}-4\frac{1}{2}$	$1\frac{3}{4}-1\frac{7}{8}$
1945	50	$2\frac{1}{2}$	$3\frac{3}{8}$	$10\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{1}{8}$	4–5	$2-2\frac{1}{16}$
1946	60	$2\frac{3}{4}$	$3\frac{3}{4}$	$11\frac{1}{2}$	4	$2\frac{3}{8}$	$4\frac{1}{2}-5\frac{1}{2}$	$2\frac{1}{8}-2\frac{1}{4}$
1947	70	3	$4\frac{1}{8}$	$12\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	5–6	$2\frac{5}{16}-2\frac{9}{16}$
1948	85	$3\frac{3}{8}$	$4\frac{5}{8}$	$13\frac{1}{2}$	5	3	$5\frac{1}{2}-6\frac{1}{2}$	$2\frac{11}{16}-2\frac{7}{8}$
1949	100	$3\frac{3}{4}$	$4\frac{7}{8}$	$14\frac{1}{2}$	$5\frac{1}{2}$	$3\frac{5}{8}$	$6\frac{1}{2}-8$	$2\frac{15}{16}-3\frac{1}{4}$

ALL DIMENSIONS IN INCHES

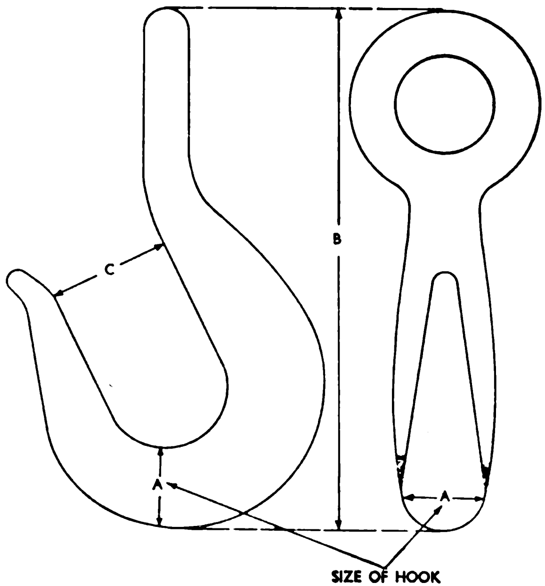
FIG. A-5. Towing shackles



B4b Patt. No.	Size of Cable to be used with	Proof Load (tons)	Dimensions				
			A	B	C	D	E
1937	$\frac{3}{4}$ to below $1\frac{1}{8}$	10	$1\frac{1}{8}$	$11\frac{1}{4}$	$5\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{4}$
1938	$1\frac{1}{8}$ to $1\frac{7}{16}$	15	$1\frac{1}{2}$	15	$7\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{5}{8}$
1936	$1\frac{1}{2}$ to 2	25	$1\frac{7}{8}$	$18\frac{9}{16}$	9	$2\frac{1}{2}$	$1\frac{7}{8}$
1939	$2\frac{1}{8}$ to $2\frac{3}{8}$	30	$2\frac{1}{4}$	24	11	3	$2\frac{5}{16}$
1940	$2\frac{1}{2}$ and above	40	$2\frac{13}{16}$	$24\frac{9}{16}$	13	$3\frac{5}{8}$	$2\frac{3}{8}$

ALL DIMENSIONS IN INCHES

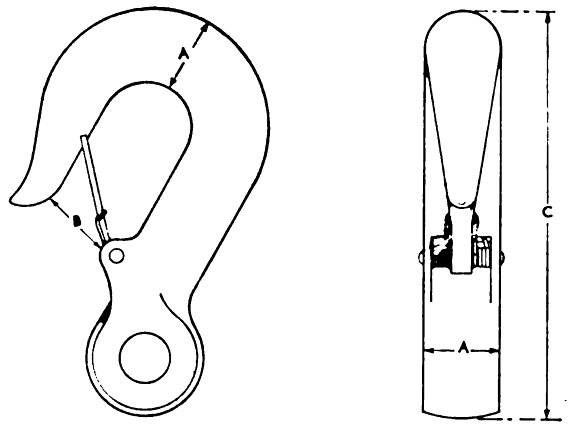
FIG. A–6. Joggle shackles

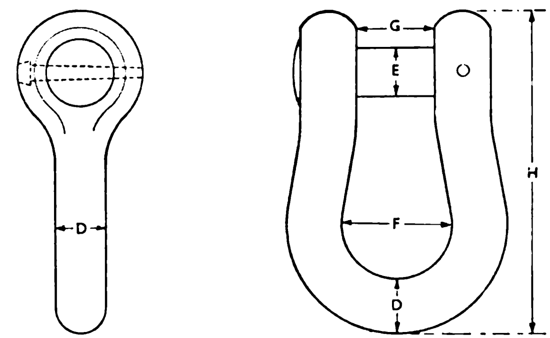


B10c Patt. No. 0263/....	4386	4387	4388	4389	4391	4394	4396	4398
Proof test (tons)	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{3}{4}$	4	7	11	$15\frac{3}{4}$
Size (A)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
Overall length (B)	$3\frac{1}{4}$	$4\frac{1}{16}$	$4\frac{7}{8}$	$6\frac{1}{2}$	$9\frac{3}{4}$	13	$16\frac{1}{4}$	$19\frac{1}{2}$
Distance in clear (C)	$\frac{3}{4}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{1}{2}$	$2\frac{1}{4}$	3	$3\frac{3}{4}$	$4\frac{1}{2}$

All Dimensions in Inches

Fig. A-7. Tackle hooks





HOOKS

B10c Patt. No. 0263/....	16973	16974	16975
For use with	$3\frac{1}{2}$ F.S.W.R.	$2\frac{1}{2}$ F.S.W.R.	4 E.S.F.S.W.R.
Diameter (A)	$1\frac{3}{4}$	$1\frac{1}{2}$	2
Distance in clear (B)	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{7}{8}$
Length (C)	$9\frac{1}{2}$	8	$11\frac{1}{4}$
Proof test (tons)	12	6	15
Spring and Tongue			
B10c Patt. No. 0263/....	17006		

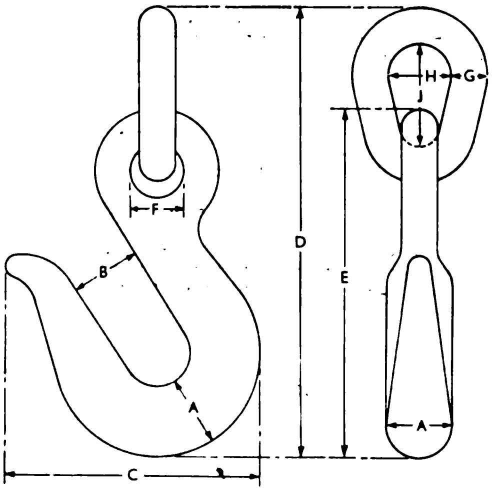
All Dimensions in Inches

SHACKLES

B10c Patt. No. 0263/....	2023	2024	2025
For use with	$3\frac{1}{2}$ F.S.W.R.	$2\frac{1}{2}$ F.S.W.R.	4 E.S.F.S.W.R.
Diameter (D)	$1\frac{1}{4}$	1	$1\frac{1}{2}$
Diameter of bolt (E)	$1\frac{1}{4}$	1	$1\frac{3}{4}$
Distance at (F)	$2\frac{1}{2}$	$2\frac{1}{8}$	3
Distance in clear (G)	$1\frac{13}{16}$	$1\frac{3}{8}$	$2\frac{1}{2}$
Length (H)	$7\frac{3}{16}$	$6\frac{1}{8}$	$9\frac{3}{16}$
Proof test (tons)	12	6	15

All Dimensions in Inches

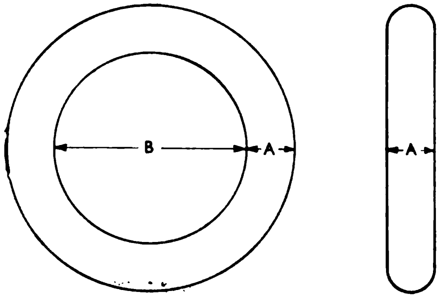
Fig. A–8. Spring hooks and shackles for picking-up ropes



B10c Patt. No. Hook with link 0263/....	5392	5391	5390	5389	5388	5386	5384	5382	5380	5378	5376	5374	5372
B10c Patt. No. Hook without link 0263/....	5413	5412	5411	5410	5409	5407	5405	5403	5401				
Size of hook (A)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
Distance in clear (B)	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
Overall width (C)	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	7	8	9	10	11	12
Overall length of hook and link (D)	$3\frac{1}{4}$	$4\frac{1}{16}$	$4\frac{7}{8}$	$5\frac{11}{16}$	$6\frac{1}{2}$	$8\frac{1}{2}$	$9\frac{3}{4}$	$11\frac{3}{8}$	13	$14\frac{5}{8}$	$16\frac{1}{4}$	$17\frac{7}{8}$	$19\frac{1}{2}$
Overall length of hook (E)	$2\frac{1}{2}$	$3\frac{1}{8}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5	$6\frac{1}{4}$	$7\frac{1}{2}$	$8\frac{3}{4}$	10	$11\frac{1}{4}$	$12\frac{1}{2}$	$13\frac{3}{4}$	15
Diameter of eye (F)	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{13}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{7}{16}$	$1\frac{9}{16}$	$1\frac{11}{16}$	$1\frac{13}{16}$
Diameter of metal in link (G)	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$
Internal diameter of link (H)	$\frac{3}{4}$	$\frac{3}{4}$	1	1	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
Internal length of link (J)	$1\frac{5}{16}$	$1\frac{5}{16}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{13}{16}$	$3\frac{1}{2}$	$3\frac{13}{16}$	$4\frac{3}{8}$	5	$5\frac{7}{16}$	$5\frac{7}{8}$	$6\frac{5}{16}$
Proof test (tons)	0·5	0·8	1·1	1·5	2	3·1	4·5	6·1	8	10·1	12·5	15·1	18
Minimum failing load (tons)	1·4	2·1	3·1	4·1	5·5	8·5	12·4	16·8	22	27·8	34·4	41·5	49 5

ALL DIMENSIONS IN INCHES

FIG. A–9. Hooks and links for boats' slings



B10c Patt. No. 0263/....	5059	5058	5057	5056	5055	5054	5053	5052	5051	5049	5047	5045	5043	5041
Diameter of metal (A)	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3
Internal diameter of ring (B)	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	8	9	10	11	12
Proof test (tons)	2·3	3·1	4	5·1	6·3	7·6	9	10·6	12·3	16	20·3	25	30·2	36
Minimum breaking load (tons)	6·8	9·2	12	15·2	18·8	22·8	27	31·8	36·8	48	60·9	76	90·6	108

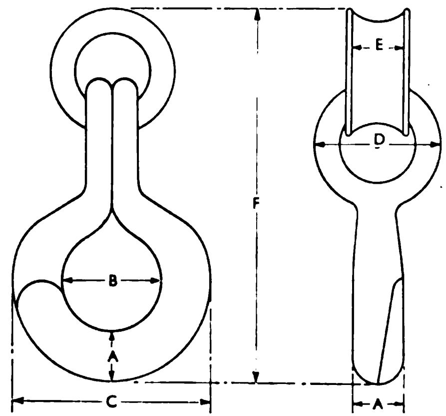
ALL DIMENSIONS IN INCHES

FIG. A–10. Rings for boats' slings

B10c Patt. No. 0263/....	4421	4422	4423	4425	4427
Registered size of hook (A)	$\frac{7}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{3}{8}$
Internal diameter (B)	$\frac{7}{8}$	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{3}{4}$
External diameter (C)	$1\frac{3}{4}$	$2\frac{1}{2}$	3	4	$5\frac{1}{2}$
External diameter of eye (D)	$1\frac{1}{16}$	$1\frac{9}{16}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{7}{16}$
Width of score (E)	$\frac{7}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	1	$1\frac{1}{4}$
Overall length (F)	3	$4\frac{3}{8}$	$5\frac{1}{4}$	7	$9\frac{5}{8}$
Proof test (tons)	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	$1\frac{1}{4}$	$2\frac{1}{4}$

ALL DIMENSIONS IN INCHES

FIG. A–11. Caliper hooks



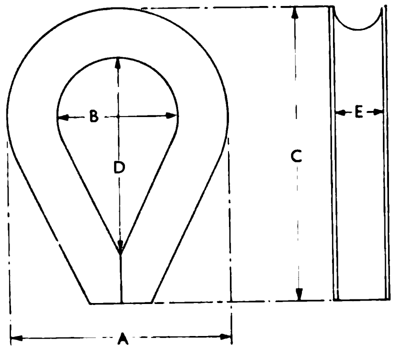
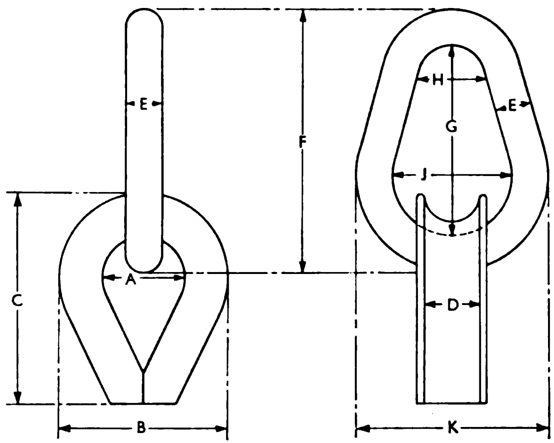


Fig. A-12. Thimbles for unserved wire rope

B10c Patt. No. 0263....	5080	5081	5082	5083	5084	5085	5086	5087	5088	5089	5090	5091	5092	5093	5094	5095
Size of wire	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	$6\frac{3}{4}$
External width (A)	1	$1\frac{7}{16}$	$1\frac{13}{16}$	$2\frac{3}{16}$	$2\frac{9}{16}$	$2\frac{15}{16}$	$3\frac{11}{16}$	$4\frac{3}{8}$	5	$5\frac{9}{16}$	$6\frac{3}{16}$	7	$7\frac{5}{8}$	$8\frac{1}{4}$	$8\frac{7}{8}$	$10\frac{3}{4}$
Internal width (B)	$\frac{9}{16}$	$\frac{13}{16}$	$1\frac{1}{16}$	$1\frac{5}{8}$	$1\frac{9}{16}$	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{1}{2}$	$2\frac{7}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	4	$4\frac{3}{8}$	$4\frac{5}{8}$	5	$6\frac{1}{4}$
External length (C)	$1\frac{3}{32}$	$1\frac{7}{8}$	$2\frac{9}{16}$	$3\frac{3}{16}$	$3\frac{5}{8}$	$4\frac{1}{8}$	$5\frac{1}{4}$	$6\frac{1}{8}$	$7\frac{1}{16}$	$7\frac{7}{8}$	$8\frac{5}{8}$	$9\frac{3}{4}$	$10\frac{5}{8}$	$11\frac{1}{8}$	$12\frac{1}{4}$	$15\frac{1}{4}$
Internal length (D)	1	$1\frac{7}{16}$	$1\frac{7}{8}$	$2\frac{5}{16}$	$2\frac{3}{4}$	$3\frac{1}{16}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5	$5\frac{1}{2}$	$6\frac{1}{8}$	7	$7\frac{11}{16}$	$8\frac{1}{16}$	$8\frac{3}{4}$	11
Width at (E)	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{11}{16}$	$\frac{13}{16}$	1	$1\frac{1}{8}$	$1\frac{5}{16}$	$1\frac{7}{16}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{15}{16}$	$2\frac{1}{8}$	$2\frac{1}{4}$

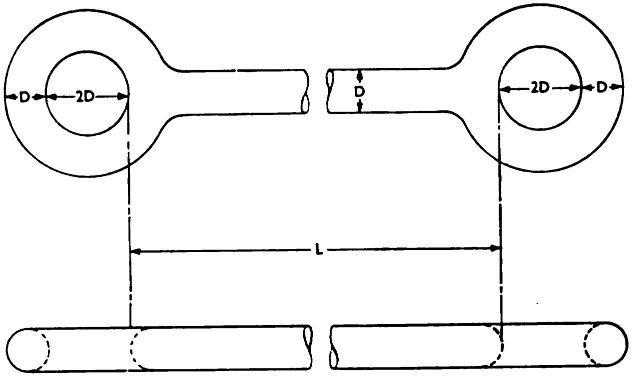
All Dimensions in Inches



B10c Patt. No.	Thimble with link 0263/....	6410	6411	6412	6414	6417
	Thimble without link 0263/....	17001	17002	17003	17004	17005
Proof test of link (tons)		$10\frac{1}{2}$	$13\frac{1}{2}$	18	25	36
Size of rope		8	9	10	12	15
Internal width of thimble (A)		$3\frac{1}{4}$	$3\frac{5}{8}$	4	$4\frac{3}{4}$	$5\frac{7}{8}$
External width of thimble (B)		$7\frac{1}{4}$	8	$8\frac{7}{8}$	$10\frac{3}{8}$	$12\frac{3}{4}$
External length of thimble (C)		9	10	11	$12\frac{7}{8}$	$15\frac{3}{4}$
Width of score (D)		$2\frac{3}{4}$	$3\frac{1}{8}$	$3\frac{1}{2}$	$4\frac{1}{4}$	$5\frac{3}{8}$
Diameter of metal in links (E)		$1\frac{5}{8}$	$1\frac{3}{4}$	$2\frac{1}{16}$	$2\frac{3}{8}$	$2\frac{3}{4}$
External length of link (F)		$11\frac{3}{8}$	$11\frac{1}{4}$	$14\frac{1}{4}$	$16\frac{5}{8}$	$19\frac{1}{4}$
Internal length of link (G)		$8\frac{1}{8}$	$8\frac{3}{4}$	$10\frac{1}{8}$	$11\frac{7}{8}$	$13\frac{3}{4}$
Width at (H)		$2\frac{7}{8}$	$3\frac{1}{8}$	$3\frac{5}{8}$	$4\frac{1}{8}$	$4\frac{7}{8}$
Width at (J)		$4\frac{7}{8}$	$5\frac{1}{4}$	$6\frac{1}{8}$	7	$8\frac{1}{4}$
External width of link (K)		$8\frac{1}{8}$	$8\frac{3}{4}$	$10\frac{1}{4}$	$11\frac{3}{4}$	$13\frac{3}{4}$

ALL DIMENSIONS IN INCHES

FIG. A-13 Thimbles and links for manila cordage



B10b Patt. No. 0263/....	16969	78	79	80	14371	82	84	87
Diameter (D)	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	1	$1\frac{1}{4}$	$1\frac{3}{4}$
Length (L)	18	18	24	30	30	42	54	60
Proof load (tons)	$1\frac{3}{8}$	$2\frac{1}{2}$	$3\frac{7}{8}$	$5\frac{5}{8}$	10	10	$15\frac{5}{8}$	$30\frac{5}{8}$

All Dimensions in Inches

Fig. A-14. Driven eyebolts

	Secured by Riveting								Secured by Welding			
Shape of base	Cir.	Rect.	Cir.	Rect.	Cir.	Rect.	Cir.	Rect.	Rect.	Rect.	Rect.	Rect.
B10b Patt. No. 0262/...	231	232	233	234	235	236	237	238	240	242	244	246
Size of rope	$1\frac{1}{2}$	$1\frac{1}{2}$	2	2	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
Length of cleat (A)	$7\frac{1}{2}$	$7\frac{1}{2}$	10	10	$12\frac{1}{2}$	$12\frac{1}{2}$	15	15	$7\frac{1}{2}$	10	$12\frac{1}{2}$	15
Height of cleat (B)	$2\frac{9}{16}$	$2\frac{9}{16}$	$3\frac{7}{16}$	$3\frac{7}{16}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$5\frac{1}{8}$	$5\frac{1}{8}$	$2\frac{9}{16}$	$3\frac{7}{16}$	$4\frac{1}{4}$	$5\frac{1}{8}$
Radius at (C)	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{3}{8}$	$\frac{11}{16}$	$\frac{15}{16}$	$1\frac{1}{8}$	$1\frac{3}{8}$

All Dimensions in Inches

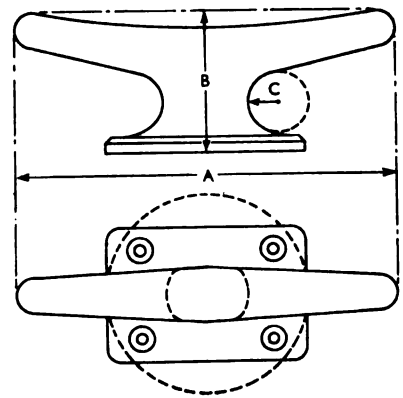
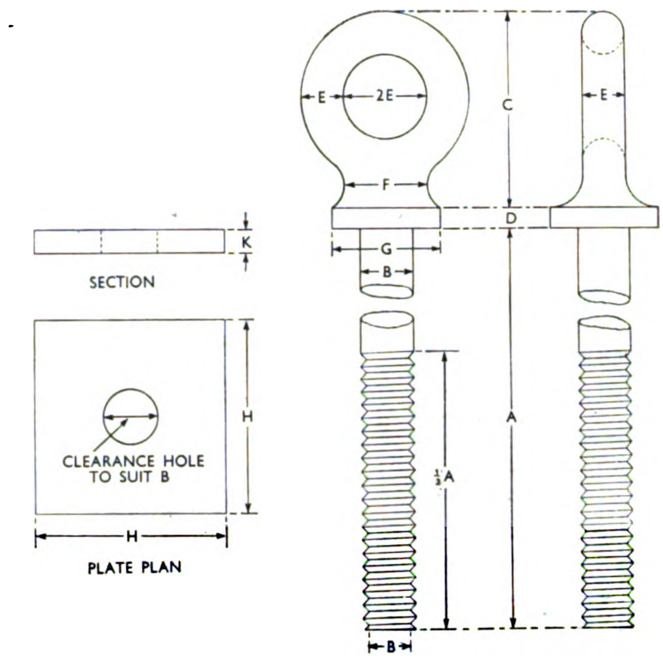


Fig. A-15. Mild steel cleats



B10c Patt. No. 0263 . . .	BOLTS									PLATES	
	A	B	B_1	C	D	E	F	G	Threads per in.	H	K
89	9	$\frac{1}{2}$	$\frac{3}{8}$	2	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{3}{4}$	$1\frac{1}{16}$	8	$2\frac{3}{8}$	$\frac{3}{16}$
14372	7	$\frac{1}{2}$	$\frac{3}{8}$	2	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{3}{4}$	$1\frac{1}{16}$	8	$2\frac{3}{8}$	$\frac{3}{16}$
14373	5	$\frac{1}{2}$	$\frac{3}{8}$	2	$\frac{1}{4}$	$\frac{7}{16}$	$\frac{3}{4}$	$1\frac{1}{16}$	8	$2\frac{3}{8}$	$\frac{3}{16}$
90	10	$\frac{5}{8}$	$\frac{19}{40}$	$2\frac{5}{16}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{5}{8}$	$\frac{1}{4}$
14374	8	$\frac{5}{8}$	$\frac{19}{40}$	$2\frac{5}{16}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{5}{8}$	$\frac{1}{4}$
14375	7	$\frac{5}{8}$	$\frac{19}{40}$	$2\frac{5}{16}$	$\frac{1}{4}$	$\frac{9}{16}$	$\frac{7}{8}$	$1\frac{1}{4}$	$6\frac{1}{2}$	$2\frac{5}{8}$	$\frac{1}{4}$
91	12	$\frac{3}{4}$	$\frac{11}{20}$	$2\frac{13}{16}$	$\frac{5}{16}$	$\frac{5}{8}$	$1\frac{1}{16}$	$1\frac{1}{2}$	5	$2\frac{3}{4}$	$\frac{1}{4}$
14376	9	$\frac{3}{4}$	$\frac{11}{20}$	$2\frac{13}{16}$	$\frac{5}{16}$	$\frac{5}{8}$	$1\frac{1}{16}$	$1\frac{1}{2}$	5	$2\frac{3}{4}$	$\frac{1}{4}$
92	18	$\frac{7}{8}$	$\frac{13}{20}$	$3\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$4\frac{1}{2}$	3	$\frac{1}{4}$
14377	12	$\frac{7}{8}$	$\frac{13}{20}$	$3\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$4\frac{1}{2}$	3	$\frac{1}{4}$
14378	8	$\frac{7}{8}$	$\frac{13}{20}$	$3\frac{5}{16}$	$\frac{5}{16}$	$\frac{3}{4}$	$1\frac{1}{4}$	$1\frac{3}{4}$	$4\frac{1}{2}$	3	$\frac{1}{4}$
93	12	1	$\frac{3}{4}$	$3\frac{3}{4}$	$\frac{3}{8}$	$\frac{7}{8}$	$1\frac{5}{16}$	$1\frac{15}{16}$	4	$3\frac{3}{8}$	$\frac{5}{16}$
14379	8	1	$\frac{3}{4}$	$3\frac{3}{4}$	$\frac{3}{8}$	$\frac{7}{8}$	$1\frac{5}{16}$	$1\frac{15}{16}$	4	$3\frac{3}{8}$	$\frac{5}{16}$

ALL DIMENSIONS IN INCHES

FIG. A-16. Screwed eyebolts

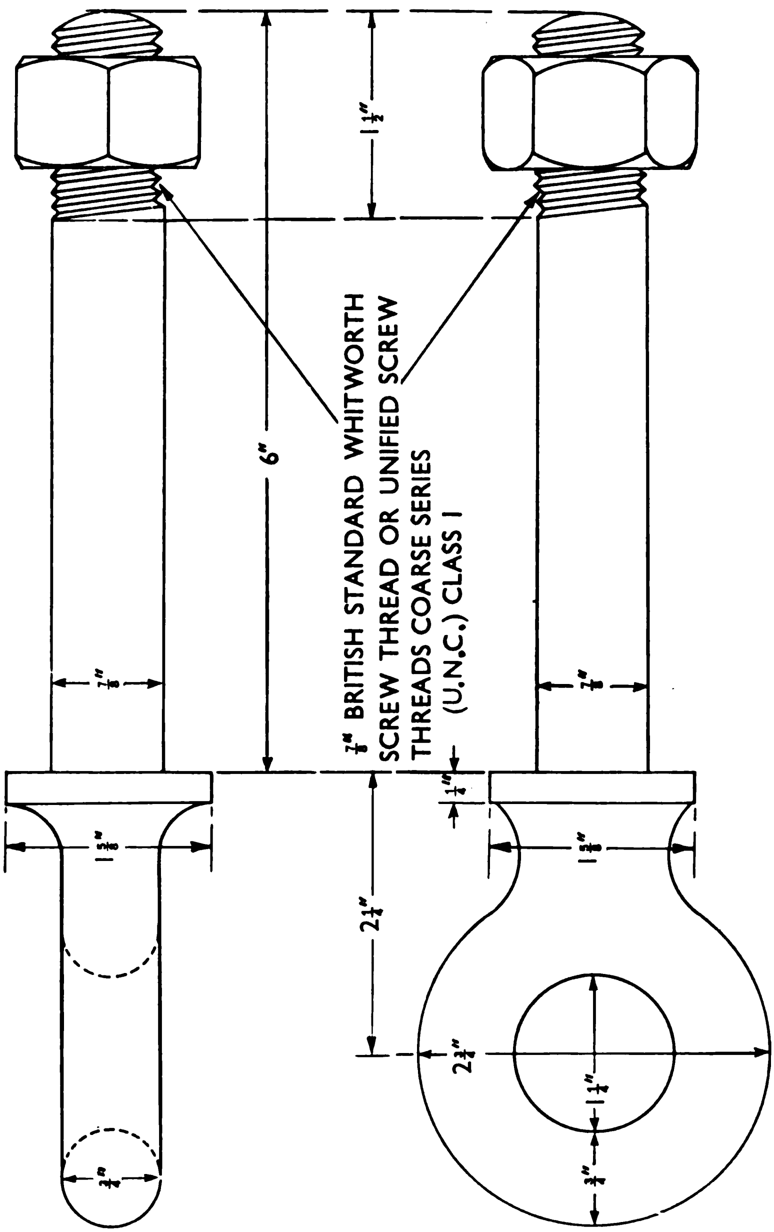
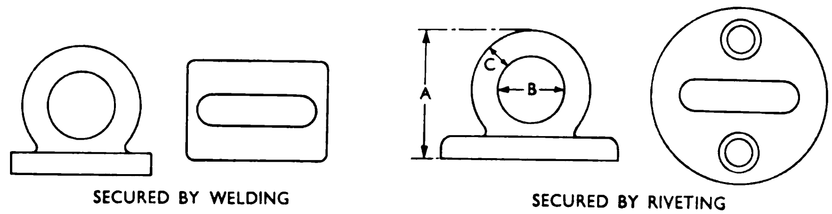


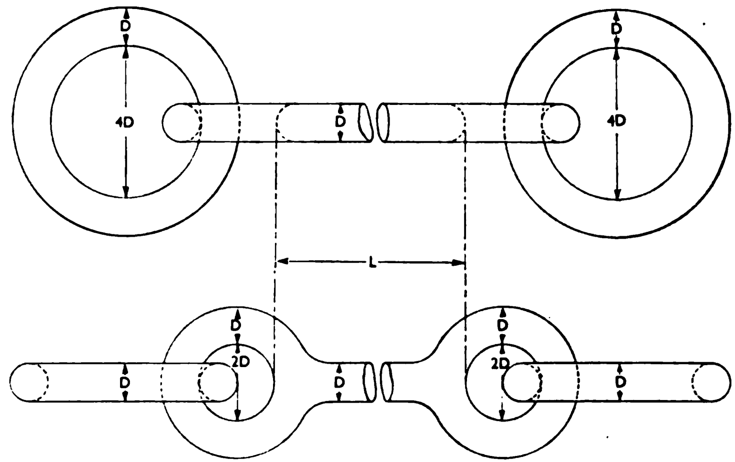
FIG. A–17. Single-ended eyebolts, Patt. 0263/94 (proof load, 5 tons)



B10b Pattern No. 0262/....	Rivet	4000	4001	4002	4003	4004	4005	4007	4009	4011	4013
	Weld	4014	4015	4016	4017		4019	4021	4023	4025	4027
Proof test (tons)		$1\frac{3}{4}$	$3\frac{1}{8}$	$4\frac{7}{8}$	7	$9\frac{9}{16}$	$12\frac{1}{2}$	$19\frac{1}{2}$	$28\frac{1}{8}$	$38\frac{1}{4}$	50
Total height (A)		$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	5	6	7	8
Diameter of eye (B)		$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Diameter of metal (C)		$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2
Number of securing rivets		2	2	2	2	2	4	4	4	4	6

ALL DIMENSIONS IN INCHES

FIG. A-18. Mild steel eyeplates



B10c Patt. Nos. 0263		16979	96	97	98	100	102	104	7753
Diameter (D)		$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2
Length (L)		18, 12 8	18, 12 9	24, 18 12	30, 24 18	42, 36 30	48, 42	48, 36	72
Proof loads in tons	Ring	$\frac{9}{16}$	1	$1\frac{9}{16}$	$2\frac{1}{4}$	4	$6\frac{1}{4}$	9	16
	Bolt	$1\frac{3}{8}$	$2\frac{1}{2}$	$3\frac{7}{8}$	$5\frac{5}{8}$	10	$15\frac{5}{8}$	$22\frac{1}{2}$	40

ALL DIMENSIONS IN INCHES

FIG. A–19. Ringbolts

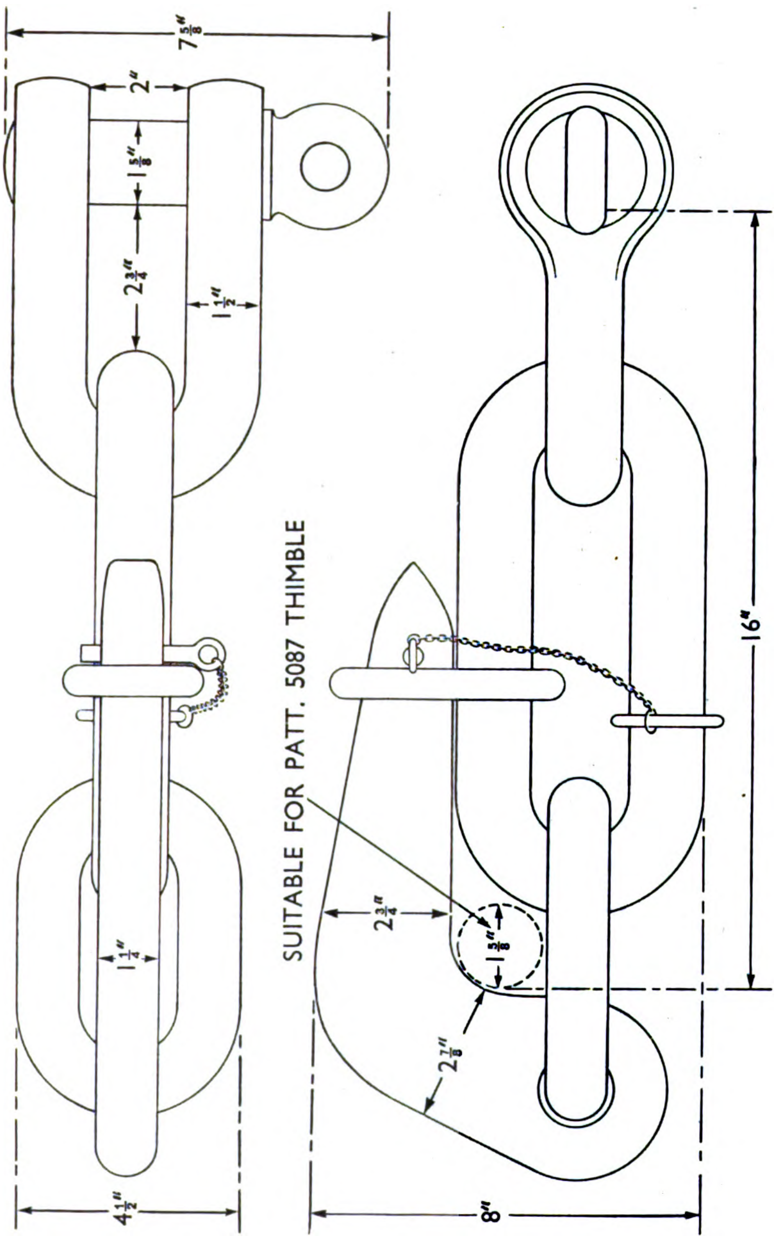
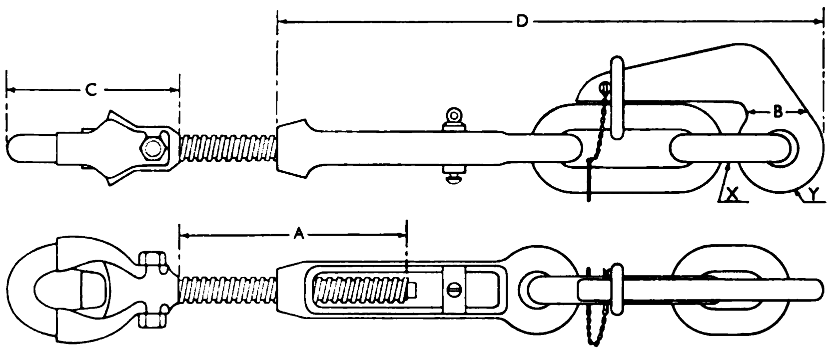


FIG. A-20. Slip and shackle for general use, B10C Patt. 0263/1915 (proof test, 18 tons)



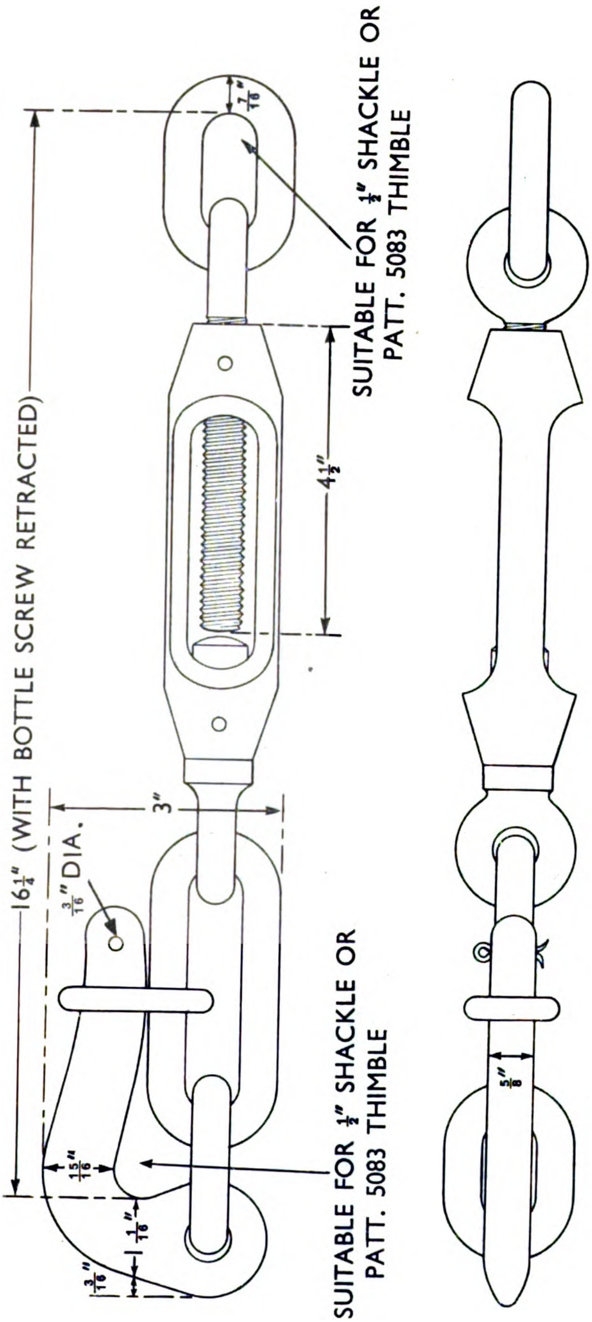
NOTE

The screw without the link X and slip Y is also supplied. All dimensions and proof tests are as for screw with slip except for overall length (see Vol. I, Fig. 8-3).

B10c Patt. No. Screw with slip 0263/....	6968	52	53	54	55	6969	58	6970
B10c Patt. No. Screw without slip 0263/....			62	63	64	6972	68	69
Proof test (tons)	44·75	36·625	29·25	19·875	12·25	6·5	3·625	2·5
Suitable size S.W.R. and F.S.W.R.	$6\frac{1}{2}$, 6	$5\frac{1}{2}$	5	$4\frac{1}{2}$, 4	$3\frac{1}{2}$	$2\frac{1}{2}$	2	$1\frac{3}{4}$, $1\frac{1}{2}$, $1\frac{1}{4}$ 1, $\frac{3}{4}$
Length of screw (A)	22	20	18	$14\frac{3}{4}$	$11\frac{3}{4}$	$8\frac{1}{2}$	$6\frac{1}{4}$	$5\frac{1}{4}$
Measurement at (B)	$7\frac{7}{8}$	$7\frac{1}{8}$	$6\frac{3}{8}$	$5\frac{1}{4}$	$4\frac{1}{8}$	3	$2\frac{1}{2}$	$1\frac{3}{4}$
Length of eye (C)	17	$15\frac{1}{2}$	$13\frac{3}{4}$	$11\frac{1}{4}$	9	$6\frac{1}{2}$	$4\frac{3}{4}$	4
Length of bottle and slip (D)	$53\frac{1}{4}$	$47\frac{1}{4}$	$43\frac{1}{8}$	$35\frac{3}{4}$	$27\frac{1}{2}$	$20\frac{1}{4}$	$15\frac{3}{8}$	$12\frac{3}{4}$

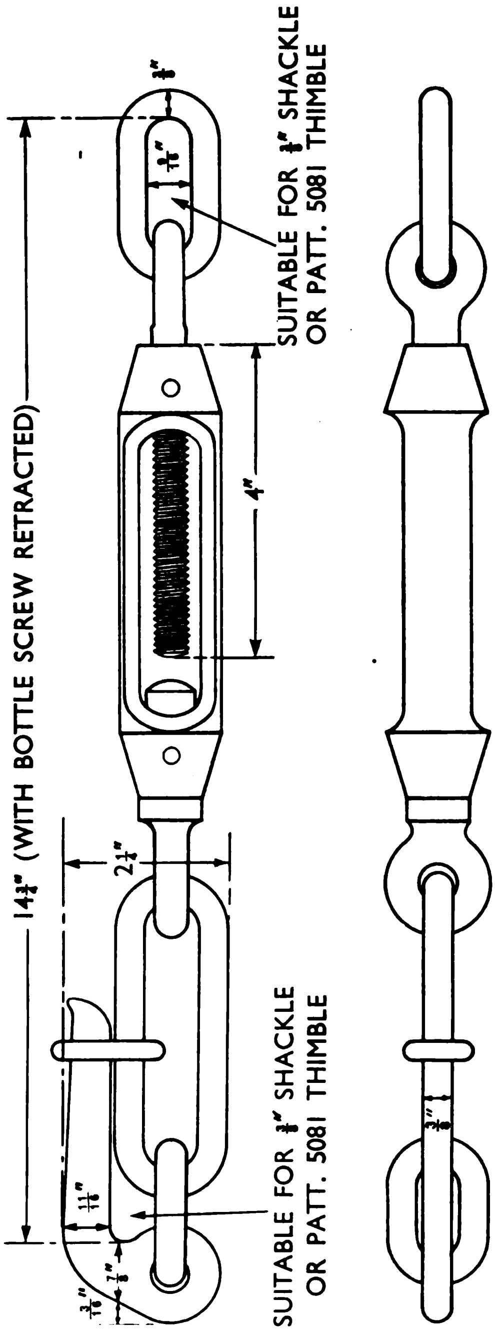
All Dimensions in Inches

FIG. A–21. Screw slip for rigging (shrouds, stays, funnel guys, etc.)



Proof test 1⅝ tons

FIG. A-22. Screw slip for guardrails, B10c Patt. 0263/16983



Proof test ¼ ton

FIG. A–23. Screw slip for guardrails, B10c Patt. 0263/1916

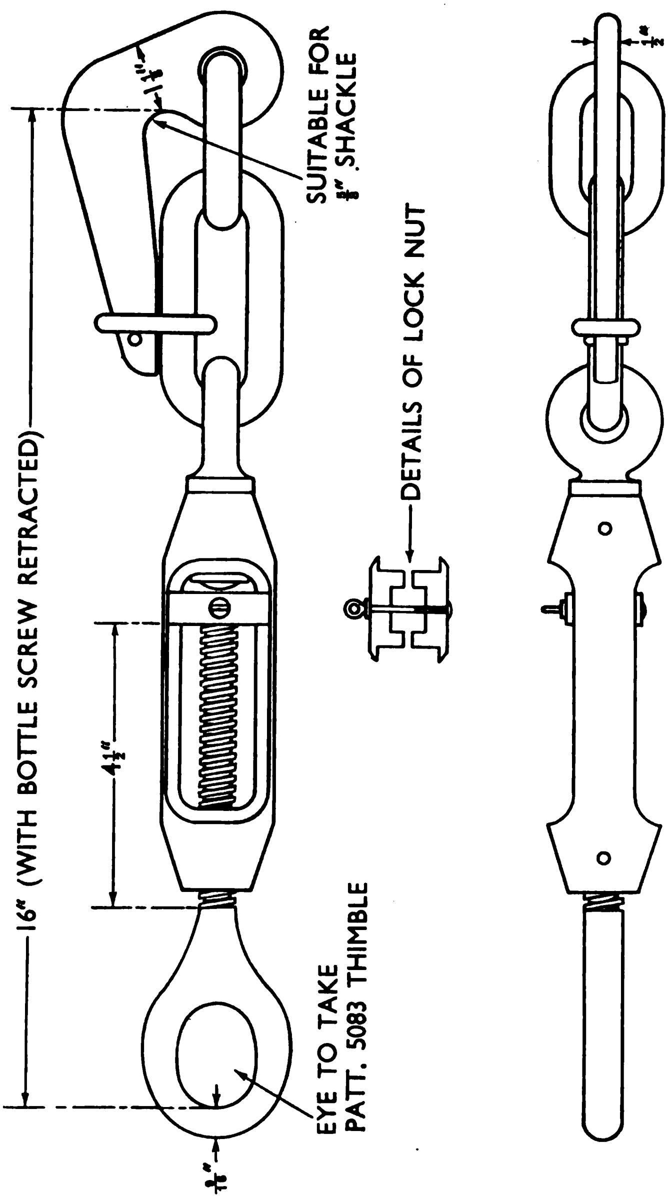


FIG. A–24. Screw slip for destroyers' davit guys, Patt. 0263/5083 (proof test, 2 tons)

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